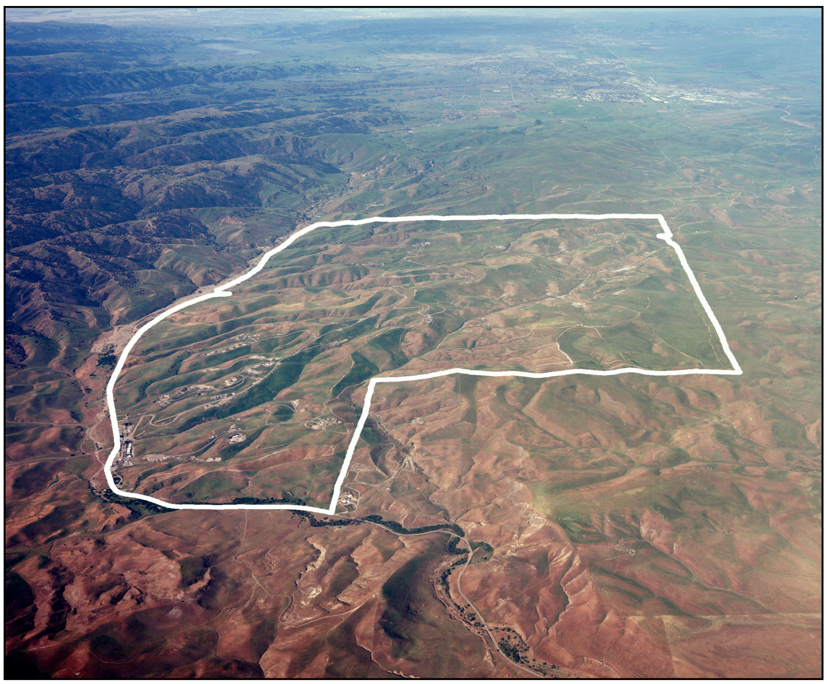
Draft

Risk-Based End State Vision for Lawrence Livermore National Laboratory Site 300

Version 2



United States Department of Energy

Livermore Site Office

Environmental Stewardship Division

Livermore, California 94550

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Acronyms and Abbreviations

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CSM	Conceptual Site Model
CSVRA	Carnegie State Vehicular Recreation Area
DOE	U.S. Department of Energy
DTSC	Department of Toxic Substances Control
EM	Environmental Management
FY	Fiscal Year
EPA	U.S. Environmental Protection Agency
GSA	General Services Area
HMX	High-Melting Explosive
LLNL	Lawrence Livermore National Laboratory
MCL	Maximum Contaminant Level
MNA	Monitored natural attenuation
NNSA	National Nuclear Safety Administration
PCB	Polychlorinated biphenyl
PRG	Preliminary Remediation Goal
RBES	Risk-Based End State
RCRA	Resource Conservation and Recovery Act
RDX	Research Department Explosive
ROD	Record of Decision
RWQCB	California Regional Water Quality Control Board
SVE	Soil vapor extraction
TBOS	Tetra-butyl-orthosilicate
TCE	Trichloroethylene
TKEBS	Tetra-kis-2-ethylbutylorthosilicate
VOC	Volatile organic compound

Executive Summary

This Risk-Based End State (RBES) Vision for Lawrence Livermore National Laboratory (LLNL) Site 300 compares environmental site conditions and remedial strategies between the current and planned future use of Site 300. It is not a decision document. The Risk-Based End State Vision focuses on ensuring that the U.S. Department of Energy (DOE) cleanup strategy is driven by risk to human and ecological receptors. DOE recognizes that the End State Vision may not agree with existing site compliance agreements or regulations. If DOE ultimately decides to seek changes to the current compliance agreements, decisions, or statutory/regulatory requirements, those changes will be made in accordance with applicable requirements and procedures.

Future land use conditions described in this document consider a 20-year timeframe, typically used by governmental organizations to evaluate growth changes in terms of population and service needs. This provides a documented foundation for land use, exposure scenarios, and other aspects of risk assessment in this Risk-Based End State Vision document. The 20-year timeframe does not apply in any way to cleanup strategies and should not be inferred to indicate that DOE anticipates that cleanup will be discontinued in 20 years (or at any arbitrary time in the future).

This document includes standardized maps that show the Current State and Risk-Based End State for the physical and surface interface; human and ecological land use; land ownership; demographics; and hazards at regional, site-specific, and site-level scales. Conceptual Site Models show, in diagram form, information regarding the hazards, pathways, receptors, and barriers to exposure (current or planned) between the hazards and the receptors.

Site Background

The primary mission of Site 300 is to function as a remote experimental testing facility where DOE conducts research, development, and testing of high explosives and integrated non-nuclear weapons components. During past Site 300 operations, contaminants were released to the environment at 73 identified release sites. The releases occurred primarily from surface spills, leaching from unlined landfills and pits, high-explosive test detonations, and past disposal of waste fluids in lagoons and dry wells (sumps). The contaminants of concern at Site 300 include the solvent trichloroethylene (TCE) and other volatile organic compounds (VOCs), high-explosive compounds, perchlorate, tritium, depleted uranium, nitrate, polychlorinated biphenyls (PCBs), dioxins, furans, silicone-based oils, and metals. Surface soil, bedrock, surface water, and ground water at Site 300 have been impacted by the releases. Extensive human health and ecological risk assessments have been performed at Site 300. These risk assessments evaluated industrial exposure scenarios onsite and unrestricted exposure scenarios offsite, consistent with anticipated future land use. In this RBES Vision, the term "unrestricted use" refers to a site condition where no further actions or institutional controls are required to protect human health or the environment from contamination, and the land and ground water may be used for any purpose.

Environmental restoration activities at Site 300 are regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Site 300 was added to the CERCLA National Priorities List in 1990. The U.S. Environmental Protection Agency

(EPA), the California Department of Toxic Substances Control (DTSC), and the California Regional Water Quality Control Board (RWQCB) provide regulatory oversight. DOE is the lead agency for environmental restoration at Site 300.

A Final Record of Decision (ROD) for the General Services Area operable unit at Site 300 was signed in 1997. In this ROD, the ground water cleanup standards were set at Maximum Contaminant Levels (MCLs) both onsite and offsite. Soil cleanup standards in the operable unit were set at an onsite industrial excess cancer risk of 10^{-6} and protection of ground water to MCLs. An Interim Site-Wide ROD was signed in 2001 for the cleanup of most of the remainder of Site 300, but did not establish site-wide ground water cleanup standards. For the purposes of this Risk-Based End State Vision, it is assumed that the ground water cleanup standards that will be set in the Final Site-Wide ROD (scheduled for completion in Fiscal Year [FY] 2007) will be no higher than MCLs both onsite and offsite, and that soil cleanup standards will be set at an onsite industrial excess cancer risk of 10^{-6} and protection of ground water to MCLs or lower.

Selected final or interim remedies for Site 300 include pumping and treating extracted ground water and soil vapor, soil excavation or removal, continued monitoring, monitored natural attenuation, and risk and hazard management. Significant progress toward cleanup has already been made at Site 300. Seventeen soil vapor and/or ground water extraction and treatment systems are in operation, and seven more will be constructed over the next several years. Several landfills containing radioactive debris have been closed, as have a number of high-explosive rinsewater lagoons and open burn facilities. Soil excavation has been completed in several areas.

Risk-Based End State Vision

For this Risk-Based End State Vision, the individual contaminant release sites at Site 300 have been grouped into two Hazard Areas:

1. **Hazard Area 1 – Facility Contaminant Releases:** This Hazard Area is defined as soil and/or ground water contamination resulting from high-explosive rinsewater lagoons and firing tables, test facilities, and machine shops in ten contaminated areas at Site 300. Contaminants include VOCs, high-explosive compounds, tritium, depleted uranium, perchlorate, PCBs, dioxins, furans, metals, and nitrate.
2. **Hazard Area 2 – Landfills:** This Hazard Area is defined as the nine landfills located within the Site 300 boundary. Radioactive and hazardous waste from site operations was placed in these unlined landfills from the 1950s through the 1980s. Engineered caps have been placed on several of the landfills; others are covered with non-engineered native soil. Releases from some of the landfills have resulted in soil and ground water contamination, primarily by VOCs, depleted uranium, and tritium.

This document evaluates a number of factors relevant to the implementation of a Risk-Based End State at Site 300, including:

- Physical and Surface Interface.
- Human and Ecological Land Use.
- Legal Ownership.
- Demographics.
- Primary and Secondary Contaminant Sources.

- Release, Transport, and Exposure Mechanisms.
- Temporary Barriers or Controls.
- Remediation, Mitigation, and Other Intervention.

Three exposure scenarios are described and compared:

1. **Current State –** Conditions at Site 300 in 2003. The DOE Office of Environmental Management (EM) is now responsible for cleanup activities. After EM mission completion (anticipated to occur at the end of FY 2008) oversight of cleanup will be transferred to the National Nuclear Safety Administration (NNSA).
2. **Current Cleanup Baseline End State –** The end state the site will be in after implementing the existing cleanup strategy. This is based on the current and anticipated requirements of the baseline work plan documents, compliance agreements and Records of Decision, and environmental regulations. The timeframe for implementing the remedial actions required to achieve this end state is the current EM mission completion date for Site 300 (FY 2008). At Site 300, these remaining remedial actions include installing several additional ground water and soil vapor extraction and treatment facilities, soil excavation, and implementing enhanced monitoring systems at some landfills. However, cleanup activities will continue after EM mission completion (e.g., long-term ground water extraction). At Site 300, compliance documents and regulations currently specify that ground water cleanup standards are MCLs or lower, both onsite and offsite, and Site 300 cleanup efforts are designed to achieve these goals. The point of compliance is the impacted ground water body, both onsite and offsite. The cleanup is projected to be complete in 2058, with a remaining cost (after FY 2003) of $175M.
3. **Risk-Based End State –** The end state the site would be in based on planned future site use that is protective of human health and the environment for that site use. The timeframe for implementing the remedial actions required to achieve this end state is the current EM mission completion date for Site 300 (FY 2008). Under a Risk-Based End State approach, the cleanup strategy would be modified to: (1) clean up offsite ground water to MCLs or lower, and (2) prevent further offsite migration of contaminants at concentrations exceeding MCLs. Ground water extraction would be limited to ensuring that MCLs are achieved and maintained offsite. Modeling to predict the residual concentration and distribution of contamination under this scenario has not yet been performed. The Risk-Based End State may require additional extraction wells and treatment facilities at the site boundary if cleanup in the interior of the site is reduced. The point of compliance would be the site boundary. No cleanup time or cost estimates have been generated for this scenario.

The only significant strategic difference between the Current Cleanup Baseline End State and the Risk-Based End State is the point of compliance for contaminated ground water. The two end states are identical in terms of exposure of offsite receptors to contaminants from Site 300, and address risk to these receptors equivalently. However, onsite cleanup of ground water under the Current Cleanup Baseline End State is intended to restore and protect ground water as a potential future resource, rather than to specifically mitigate risk. The Risk-Based End State presents a scenario based only on risk, but does not remediate onsite ground water to levels protective of ground water as a potential future resource.

For each exposure pathway where unacceptable carcinogenic risk or noncarcinogenic hazard was identified in the baseline risk assessment, barriers to exposure are described for both the Current Cleanup Baseline End State and the Risk-Based End State. For each exposure barrier: (1) residual risk (risk remaining at the End State, if available) and, (2) a failure analysis are presented.

Variances

The variances between the Current Cleanup Baseline End State and the Risk-Based End State are the differences between current cleanup plans and/or regulatory agreements and the Risk-Based End State Vision. For Site 300, a variance has been identified based on input from the regulatory agencies, local government, and the community.

The Current Cleanup Baseline End State assumes that all ground water contaminated by Site 300 activities must ultimately be remediated in a manner consistent with current environmental regulations and existing compliance agreements, both onsite and offsite. The impacted ground water body is assumed to be the point of compliance. The Risk-Based End State Vision assumes that the site boundary would be the point of compliance for contaminants in ground water. The Risk-Based End State Vision is not consistent with Federal and State environmental regulations and existing compliance agreements in terms of onsite cleanup of ground water.

This issue is discussed in more detail in the Variance Report attached to this Risk-Based End State Vision document.

1. Introduction

This Risk-Based End State (RBES) Vision for Lawrence Livermore National Laboratory (LLNL) Site 300 was prepared in response to one of the Corporate Projects ("A Cleanup Program Driven by Risk-Based End States") established by the U.S. Department of Energy (DOE) Office of Environmental Management (EM) in response to the EM Top-to-Bottom Review completed in 2002. DOE sites are directed to create Risk-Based End State Visions for submission to the Assistant Secretary for Environmental Management. This Site 300 Risk-Based End State Vision was prepared according to the September 2003 *Guidance for Developing a Risk-Based End State Vision,* the December 2003 *Clarification Addendum to Guidance for Developing a Site-Specific Risk-Based End State Vision,* and to comply with DOE Policy 455.1, *Use of Risk-Based End State*. One of the primary goals of the Risk-Based End State Corporate Project is to transform the varying applications and/or versions of essential management tools (e.g., land-use maps, conceptual site models) developed at individual DOE sites into a single unified approach.

This Risk-Based End State Vision focuses on ensuring that the U.S. Department of Energy (DOE) cleanup strategy is driven by risk to human and ecological receptors. It is not a decision document. DOE recognizes that the End State Vision may not agree with existing site compliance agreements or regulations. The Risk-Based End State approach attempts to gain a common acceptance of the site-wide post-remediation future. After Risk-Based End States are developed, sites will re-evaluate their cleanup activities and strategic approaches to determine if it is appropriate to change site baseline documents and renegotiate agreements with the regulatory agencies. If DOE ultimately decides to seek changes to the current compliance agreements, decisions, or statutory/regulatory requirements, those changes will be made in accordance with applicable requirements and procedures.

Future land use conditions described in this document consider a 20-year timeframe. This timeframe is typically used by governmental organizations to evaluate growth changes in terms of population and service needs. This provides a documented foundation for land use, exposure scenarios, and other aspects of risk assessment in this Risk-Based End State Vision document. The 20-year timeframe does not apply in any way to cleanup strategies and should not be inferred to mean that DOE anticipates that cleanup will be discontinued in 20 years (or at any arbitrary time in the future). This Risk-Based End State Vision is consistent with the National Nuclear Safety Administration (NNSA) Ten Year Comprehensive Site Plan.

The scope of this Risk-Based End State Vision for the Site 300 includes evaluating strategies to perform cleanup of contaminants released during past operations. Waste management and facility decontamination/decommissioning are not included because these activities are not likely to impact future land use or cause risk to humans or ecological receptors.

The primary sources of information used to prepare this document include:

- LLNL Site 300 Federal Facility Agreement Under CERCLA Section 120 (U.S. DOE, 1992).
- Final Site-Wide Remedial Investigation Report, LLNL Site 300 (Webster-Scholten, 1994).

- Final Feasibility Study for the General Services Area at LLNL Site 300 (Rueth and Berry, 1995).
- Addendum to the Site-Wide Wide Remedial Investigation Report, LLNL Site 300: Building 850/Pit 7 Complex Operable Unit (Taffet et al., 1996).
- Final Record of Decision for the General Services Area Operable Unit at LLNL Site 300 (U.S. DOE, 1997).
- Final Site-Wide Feasibility Study for LLNL Site 300 (Ferry et al., 1999).
- Interim Site-Wide Record of Decision for LLNL Site 300 (U.S. DOE, 2001).
- Remedial Design Work Plan for Interim Remedies at LLNL Site 300 (Ferry et al., 2001).
- Compliance Monitoring Plan/Contingency Plan for Interim Remedies at LLNL Site 300 (Ferry et al., 2002).
- Interim Remedial Design for the Building 854 Operable Unit at LLNL Site 300 (Daily et al., 2003.
- Draft Site Wide Environmental Impact Statement for the Continued Operation of LLNL and Support of Stockpile Stewardship and Management Program Environmental Impact Statement (DOE, 2004).
- LLNL Site 300 Baseline Work Plan.
- Alameda and San Joaquin County Planning Departments.
- City of Tracy.

Full references are provided in Section 5.

1.1. Organization

This document presents a series of standardized maps that show the Current State and Risk-Based End State for the physical and surface interface; human and ecological land use; land ownership; demographics; and hazards at regional, site-specific, and site-level scales. Chapter 2 of this document presents regional-scale maps of the physical and surface interface, and human and ecological land use. Chapter 3 presents site-specific maps that show the physical and surface interface, human and ecological land use, legal ownership and demographics. Chapter 4 presents Conceptual Site Models and Hazard Maps for each defined Hazard Area. The text discusses features not apparent on the maps or that supplement the maps and differences between the Current State and Risk-Based End State maps and Conceptual Site Models.

1.2. Site 300 Mission

The primary mission of LLNL Site 300 is to function as a remote experimental testing facility where DOE conducts research, development, and testing of high explosives and integrated non-nuclear weapons components. This work includes formulating, processing, machining, assembling, and detonating explosives. Site 300 activities also include hydrodynamic testing, verifying computer simulation results, obtaining state-of-the-art data for explosive materials, evaluating material behavior and the quality and uniformity of implosion, and evaluating the performance of post-nuclear test design. Statements from Congressional representatives and the Administration regarding the importance of the National Laboratories to the nation's continued scientific and defense interests indicate that Site 300 will continue its current mission for the foreseeable future.

1.3. Status of the Site 300 Cleanup Program

During past Site 300 operations, contaminants were released to the environment at 73 identified release sites. The releases occurred primarily from surface spills, leaching from unlined landfills and pits, high-explosive test detonations, and past disposal of waste fluids in lagoons and dry wells (sumps). The contaminants of concern at Site 300 include the solvent trichloroethylene (TCE) and other volatile organic compounds (VOCs), high-explosive compounds, perchlorate, tritium, depleted uranium, nitrate, polychlorinated biphenyls (PCBs), dioxins, furans, silicone-based oils, and metals. Surface soil, bedrock, surface water, and ground water at Site 300 have been impacted by the releases. VOCs, high-explosives compounds, perchlorate, nitrate, tritium, and depleted uranium are present in ground water in concentrations above drinking water standards.

Environmental restoration activities at Site 300 are regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Site 300 was added to the CERCLA National Priorities List in 1990. The U.S. Environmental Protection Agency (EPA), the California Department of Toxic Substances Control (DTSC), and the California Regional Water Quality Control Board (RWQCB) provide regulatory oversight. DOE is the lead agency for environmental restoration at Site 300.

Extensive human health and ecological risk assessments have been performed at Site 300. These risk assessments evaluated industrial exposure scenarios onsite and unrestricted exposure scenarios offsite. In this RBES Vision, the term "unrestricted use" refers to a site condition where no further actions or institutional controls are required to protect human health or the environment from contamination, and the land and ground water may be used for any purpose.

A Final Record of Decision (ROD) for the General Services Area operable unit at Site 300 was signed in 1997 (U.S. DOE, 1997). In this ROD, the ground water cleanup standards were set at Maximum Contaminant Levels (MCLs) both onsite and offsite. Soil cleanup standards in the operable unit were set at an onsite industrial excess cancer risk of 10^{-6} and protection of ground water to MCLs. An Interim Site-Wide ROD (U.S. DOE, 2001) was signed for the cleanup of most of the remainder of Site 300, but did not establish site-wide ground water cleanup standards. For the purposes of this Risk-Based End State Vision, it is assumed that the ground water cleanup standards that will be set in the Final Site-Wide ROD (scheduled for completion in Fiscal Year [FY] 2007) will be no higher than MCLs both onsite and offsite, and that soil cleanup standards will be set at an onsite industrial risk of 10^{-6} and protection of ground water to MCLs or lower.

The Interim Site-wide ROD does not apply to the Pit 7 Landfill Complex for which a focused Remedial Investigation/Feasibility Study (RI/FS) is being prepared, or to Building 865 (the Advanced Test Accelerator), Building 812, and the former Sandia Test Site areas where additional characterization is underway.

Subsequent to the Interim Site-Wide ROD, a Remedial Design Work Plan (Ferry et al., 2001) and a Compliance Monitoring Plan/Contingency Plan (Ferry et al., 2002) were produced. The Remedial Design Work Plan describes the strategic approach and schedule for implementing the remedies selected in the Interim Site-Wide ROD. The Compliance Monitoring Plan/Contingency Plan contains the procedures DOE will use to monitor the progress of remediation, detect any new contaminant releases, control risks and hazards, manage the data obtained during monitoring, and includes contingency procedures and measures DOE will implement if cleanup does not proceed as planned.

Selected final or interim remedies for Site 300 include pumping and treating extracted ground water and soil vapor, soil excavation or removal, continued monitoring, monitored natural attenuation, and risk and hazard management. Significant progress toward cleanup has already been made at Site 300. Seventeen soil vapor and/or ground water extraction and treatment systems are in operation, and more will be constructed in the next several years. Some landfills containing radioactive debris have been closed, as have a number of high-explosive rinsewater lagoons and open burn facilities. Soil excavation has been completed in several areas.

The overall objective of the Site 300 cleanup is to achieve a rapid, efficient, and cost-effective remediation within budgetary constraints and in compliance with regulatory requirements. The remediation strategy emphasizes risk reduction. In agreement with the regulatory agencies and the neighboring community, the following objectives have been established for the Site 300 cleanup:

- Prevent contamination of water-supply wells and associated risk to human health and loss of beneficial uses of ground water.
- Prevent exposure of onsite workers to contaminants and reduce the current unacceptable risk.
- Control and prevent further offsite plume migration.
- Reduce contaminant concentration and mass in the vadose (unsaturated) zone and ground water to prevent further impacts to water-supply aquifers and additional plume migration.
- Control contaminant sources.
- Manage risk to ecological receptors.

Milestones for cleanup at Site 300 are established in conjunction with the overseeing regulatory agencies with input from the local community, and are specified in a schedule that incorporates milestone deliverables from the Site 300 Federal Facility Agreement (U.S, DOE, 1992), Remedial Design Work Plan (Ferry et al., 2001), and various area-specific Remedial Design documents.

2. Risk-Based End State Vision: Regional Context

2.1. Physical and Surface Interface

The regional-scale Current State and Risk-Based End State physical and surface interface for Site 300 is shown on Figure 2.1a,b. Site 300 is located between the cities of Livermore and Tracy, California. Site 300 is situated in hilly terrain with moderate to steep slopes. Rural Corral Hollow Road is the only access to Site 300, and the entire facility perimeter is fenced and patrolled by security staff. As further described in Section 3, most of Site 300 is bordered by private land, primarily ranches, except for a State off-road vehicle recreation area to the south-southwest and a State ecological preserve to the east. The seismically-active Greenville fault zone is located approximately 3 miles southwest of Site 300.

There are no differences between the Current State and Risk-Based End State.

2.2. Human and Ecological Land Use

The regional-scale Current State and Risk-Based End State human and ecological land use for Site 300 is shown on Figure 2.2a,b, respectively. Figure 2.2a shows that Site 300 contains areas designated as endangered species habitat. As discussed further in Section 3.2, critical habitats for the large flowered fiddleneck, Alameda whipsnake, California red-legged frog, and the valley elderberry longhorn beetle exist or are proposed for portions of Site 300. Site 300 is also within the northern end of the habitat range for the San Joaquin kit fox. Most of the land in the vicinity of Site 300 is used for cattle and sheep grazing.

There are no differences between the Current State and Risk-Based End State.

3. Site-Specific Risk-Based End State Description

3.1. Physical and Surface Interface

The site-specific Current State and Risk-Based End State physical and surface interface is shown on Figure 3.1a,b. Site 300 consists of approximately 11 square miles of moderately hilly terrain. The hills and canyons are generally oriented northwest-southeast. The primary surface water drainage is via east-flowing ephemeral Corral Hollow Creek bordering Site 300 to the south and southeast.

Nine active water supply wells exist at or near the southern Site 300 boundary. Five of these wells supply private ranches, two wells supply the Carnegie State Vehicular Recreational Area (CSVRA) to the south, and two are used for Site 300 water supply. None of these wells contain contaminants above drinking water standards. The springs shown on Figure 3.1a,b are characterized by very low flow, and many are actually slow seepages or moist areas. These springs and two vernal pools comprise the majority of the onsite wetlands. The remaining wetlands are the result of industrial water discharges.

There are no differences between the Current State and Risk-Based End State.

3.2. Human and Ecological Land Use

Figures 3.2a and 3.2b, respectively, show the site-specific Current State and Risk-Based End State human and ecological land use at and adjacent to Site 300. Most of Site 300 is undeveloped land. Site 300 has three remote explosive test facilities supported by a chemistry processing area, a weapons test area, maintenance facilities, and a General Services Area at the Site 300 entrance. Figure 3.2a shows that agricultural land (used primarily for sheep and cattle grazing) essentially surrounds Site 300. Future residential development is planned northeast of Site 300, although development of this parcel has not yet begun (Figure 3.2b). Open space/recreational land south of Site 300 is the 5,000-acre CSVRA, an outdoor recreational facility for private and commercial off-road motorcycle riding and racing. The open space/recreational land east of Site 300 is a California Department of Fish and Game ecological preserve. A privately-owned parcel immediately east of Site 300 and north of the State ecological preserve shown on Figure 3.2a as “Restricted Access Commercial” is used to store fireworks.

Figure 3.2a also shows that Site 300 contains habitat for endangered species. Critical habitat for the large flowered fiddleneck occupies 91 acres in the southwestern portion of Site 300. Localized wetlands that are habitat for the Alameda whipsnake are present in the southern half of Site 300. California red-legged frog habitat occurs in the southwestern portion of Site 300. Localized tiger salamander habitat exists in the northeastern and southeastern portions of Site 300. About 25% of Site 300 is kit fox habitat. Valley elderberry longhorn beetle habitat exists in the east-central, southeastern, and southwestern part of Site 300, and in the ecological preserve to the east. Two localized diamond-petaled poppy habitat areas occur in the southwestern and western portions of Site 300.

Figure 3.2b shows the Risk-Based End State land use assuming that the currently proposed critical habitat areas are adopted as the final designations. Figure 3.2b also shows a planned residential development adjacent to the north and northeast boundaries of Site 300.

3.3. Site Context Legal Ownership

Current State and Risk-Based End State land ownership at and near Site 300 at the site context scale is shown on Figure 3.3a,b. Most of Site 300 is bordered by privately owned property except for the State-owned CSRVA to the southwest, and the State ecological preserve to the east.

There are no differences between the Current State and Risk-Based End State.

3.4. Site Context Demographics

Figure 3.4a,b shows the site context site population density in the Site 300 vicinity for the Current State and Risk-Based End State. The population density surrounding Site 300 is less than 150 people per square mile. The California Department of Parks and Recreation reports that there are about 300,000 visitors per year to the CSVRA. This is unlikely to change significantly in the next 20 years, except for the proposed residential development northeast of Site 300.

Although there is a projected 20.8% overall population increase for San Joaquin County by 2010, there are no detailed future population density projections available.

4. Hazard Specific Discussion

During past Site 300 operations, contaminants were released to the environment from surface spills and piping leaks, leaching from unlined landfills and pits, high-explosive test detonations, and disposal of waste fluids in lagoons and dry wells (sumps). Environmental investigations have found 73 locations where contaminants were released to the environment. In some cases, ground water contamination has resulted from these releases. The primary contaminants of concern at Site 300 include:

- VOCs, primarily TCE. At Site 300, VOCs were commonly used as heat-exchange fluids and degreasing solvents.
- High-explosive compounds, primarily High-Melting Explosive (HMX) and Research Department Explosive (RDX) that were formulated and tested at Site 300.
- Perchlorate, a component of many explosives.
- Tritium and depleted uranium, used in explosive tests.
- Nitrate resulting from releases of explosives formulation rinsewater, septic-system effluent, and/or leaching of naturally-occurring nitrate from bedrock.
- PCBs, dioxins, and furans that were present in capacitors and transformers destroyed in explosive tests.
- Tetra-butyl-orthosilicate (TBOS) and tetra-kis-2-ethylbutylorthosilicate (TKEBS), silicone oils that were used in TCE-based heat-exchange systems to lubricate pumps and seals.
- Metals (primarily beryllium, cadmium, lead, copper, and zinc) that occur as byproducts of explosives tests and in rinsewater discharges.

The maximum current concentrations of contaminants in ground water are presented in Table 1.

In 2001, DOE completed an Interim Site-Wide ROD for Site 300 (U.S. DOE, 2001). This ROD was designated as interim to ensure that cleanup continues to reduce risks associated with past contaminant releases while additional site characterization, evaluation of remediation technologies, and negotiation of final ground water cleanup standards proceeds. The Interim ROD specified remedies for most of the contaminant releases at Site 300, but did not include some areas where site characterization is in progress or a final remedy has already been selected. The remedies included soil vapor and ground water extraction, soil excavation, monitored natural attenuation, enhanced monitoring of landfills, and risk and hazard management. A Final ROD is scheduled for completion in FY 2007.

For this Risk-Based End State Vision, the individual contaminant release sites at LLNL Site 300 have been grouped into two Hazard Areas:

1. **Hazard Area 1 – Facility Contaminant Releases:** This Hazard Area is defined as soil and/or ground water contamination resulting from high-explosive rinsewater lagoons and firing tables, test facilities, and machine shops in ten contaminated areas at Site 300. Contaminants include VOCs, high-explosive compounds, tritium, depleted uranium, perchlorate, PCBs, dioxins, furans, metals, and nitrate.

2. **Hazard Area 2 – Landfills:** This Hazard Area is defined as the nine landfills located within the Site 300 boundary. Radioactive and hazardous waste from site operations was placed in these unlined landfills from the 1950s through the 1980s. Engineered caps have been placed on several of the landfills; others are covered with non-engineered native soil. Releases from some of the landfills have resulted in soil and ground water contamination, primarily by VOCs, depleted uranium, and tritium.

Three exposure scenarios are described and compared:

1. **Current State –** Conditions at Site 300 in 2003. The DOE Office of Environmental Management (EM) is now responsible for cleanup activities. After EM mission completion (anticipated to occur at the end of FY 2008) oversight of cleanup will be transferred to the National Nuclear Safety Administration (NNSA).
2. **Current Cleanup Baseline End State –** The end state the site will be in after implementing the existing cleanup strategy. This is based on the current and anticipated requirements of the baseline work plan documents, compliance agreements and Records of Decision, and environmental regulations. The timeframe for implementing the remedial actions required to achieve this end state is the current EM mission completion date for Site 300 (FY 2008). At Site 300, these remaining remedial actions include installing several additional ground water and soil vapor extraction and treatment facilities, soil excavation, and implementing enhanced monitoring systems at some landfills. However, cleanup activities will continue after EM mission completion (e.g., long-term ground water extraction). At Site 300, compliance documents and regulations currently specify that ground water cleanup standards are MCLs or lower, both onsite and offsite, and Site 300 cleanup efforts are designed to achieve these goals. The point of compliance is the impacted ground water body, both onsite and offsite. The cleanup is projected to be complete in 2058, with a remaining cost (after FY 2003) of $175M.
3. **Risk-Based End State –** The end state the site would be in based on planned future site use that is protective of human health and the environment for that site use. The timeframe for implementing the remedial actions required to achieve this end state is the current EM mission completion date for Site 300 (FY 2008). Under a Risk-Based End State approach, the cleanup strategy would be modified to: (1) clean up offsite ground water to MCLs or lower, and (2) prevent further offsite migration of contaminants at concentrations exceeding MCLs. Ground water extraction would be limited to ensuring that MCLs are achieved and maintained offsite. Modeling to predict the residual concentration and distribution of contamination under this scenario has not yet been performed. The Risk-Based End State may require additional extraction wells and treatment facilities at the site boundary if cleanup in the interior of the site is reduced. The point of compliance would be the site boundary. No cleanup time or cost estimates have been generated for this scenario.

The only significant strategic difference between the Current Cleanup Baseline End State and the Risk-Based End State is the point of compliance for contaminated ground water. The two end states are identical in terms of exposure of offsite receptors to contaminants from Site 300, and address risk to these receptors equivalently. However, onsite cleanup of ground water under the Current Cleanup Baseline End State is intended to restore and protect ground water as a potential future resource, rather than to specifically mitigate risk. The Risk-Based End State presents a scenario based only on risk, but does not remediate onsite ground water to levels protective of ground water as a potential future resource.

A baseline risk assessment was included in the Site-Wide Remedial Investigation report for Site 300 (Webster-Scholten, 1994) and an addendum to that report (Taffet et al., 1996). Risk assessment information is also provided in the Site-Wide Feasibility Study (Ferry et al., 1999), the Interim ROD (U.S. DOE, 2001), the Feasibility Study for the General Services Area Operable Unit (Rueth and Berry, 1995), the Final ROD for the General Services Area Operable Unit, (U.S. DOE, 1997), the Interim Remedial Design for the Building 854 Operable Unit (Daily et al., 2003), and the Compliance Monitoring Plan/Contingency Plan for Interim Remedies (Ferry et al., 2002).

The term “risk” is used to refer to carcinogenic health effects, and “hazard” is used to refer to non-carcinogenic (toxic) health effects as expressed by the hazard quotient or hazard index. The term “hazard” does not refer to physical hazards, such as construction-related injuries.

The baseline human health risk assessment evaluated two exposure scenarios: onsite industrial and offsite residential. Both scenarios assumed that no soil or ground water remediation would be performed at Site 300. The adult onsite worker scenario assumed that Site 300 workers could be exposed to contaminants by:

1. Inhaling contaminants volatilizing from soil into the atmosphere or into buildings.
2. Inhaling contaminants bound to resuspended surface soil.
3. Direct dermal contact with contaminated soil.
4. Incidental ingestion of contaminated soil.

Recreational use of the site and intruder/trespasser exposure scenarios are not applicable to Site 300 and were not evaluated in the baseline risk assessment.

Unacceptable onsite risk or hazard was identified for the following areas:

- General Services Area.
- Building 834.
- Pit 6 Landfill.
- High Explosives Process Area.
- Building 850.
- Building 854.
- Building 832 Canyon.
- Building 833.

Acceptable levels are defined by the Site 300 Remedial Action Objectives as carcinogenic risk below 1×10^{-6} and non-carcinogenic hazard index below 1.

The offsite residential exposure scenario assumed that members of the public living adjacent to Site 300 could potentially be exposed to contaminated ground water withdrawn from private offsite water-supply wells, but not to contaminated soil within the site boundary, or to resuspended particulates or volatilized contaminants transported through the atmosphere across the site boundary. In the baseline risk assessment, future impacts to ground water quality (assuming no remediation was performed at Site 300) were estimated at nearby private water-supply wells and at hypothetical water-supply wells that might be installed at the Site 300 boundary downgradient from onsite ground water contaminant plumes.

The risks and hazards to human and receptors are summarized in Table 2. Hazards to ecological receptors are summarized in Table 3. The Site-wide Hazard Map for the Current State and Risk-Based End State exposure scenarios is presented as Figure 4.0a,b. A Site-wide Hazard map showing the southeastern portion of Site 300 is presented as Figure 4.0a,b (detail).

On some Hazard Map and Conceptual Site Model figures, the Current State and the Risk-Based End State exposure scenarios are combined because the only significant difference between the scenarios is the point of compliance for ground water.

4.1. Hazard Area 1 – Facility Contaminant Releases

Hazard Area 1 at Site 300 is defined as soil and/or ground water contamination resulting from high-explosive rinsewater lagoons and firing tables, test facilities, and machine shops in ten contaminated areas at Site 300. Contaminant releases in these areas at Site 300 are grouped into a single Hazard Area due to similarities in:

- **Release Mechanism –** The releases are predominantly point source, resulting from discharges to the ground surface or shallow soil.
- **Primary and Secondary Sources –** The environmental media affected are ambient air, soil, bedrock, surface water, and ground water.
- **Release, Transport, and Exposure Mechanisms –** These factors are similar for all release areas in Hazard Area 1, and include surface and subsurface flow and transport, and ingestion, inhalation, and dermal exposure pathways.
- **Extent of Contamination –** Contamination from release areas in Hazard Area 1 is generally contained within the Site 300 boundary. Where offsite contamination exists, aggressive remedial actions are underway.
- **Temporary Barriers or Controls –** All release areas in Hazard Area 1 share similar controls, such as measures to restrict access to contaminated areas.
- **Remediation, Mitigation, and Other Interventions –** Remediation is underway at most of the release areas in Hazard Area 1. Remedial technologies include soil vapor and/or ground water extraction and treatment, monitored natural attenuation, and soil excavation.
- **Future Land Use –** All release areas in Hazard Area 1 are located within the Site 300 boundary. It is assumed that DOE will maintain control of Site 300 for the foreseeable future.

The following characteristics of Hazard Area 1 are included in the Current State and Risk-Based End State exposure scenarios:

- Hazard Area description.
- Primary and secondary sources of contaminants.
- Release, transport, and exposure mechanisms, including human and ecological receptors.
- Temporary barriers or controls.

- Remediation, mitigation, or other intervention.

The Current State and Risk-Based End State maps for Hazard Area 1 are presented as Figures 4.1a1 and 4.1b1, respectively. The Current State and Risk-Based End State Conceptual Site Model is shown on Figure 4.1a2,b2. On the Conceptual Site Model diagram, active pathways are shown as solid lines, blocked pathways are shown as dashed lines, and incomplete pathways are shown as dotted lines. Barriers are shown as heavy vertical or horizontal lines across the exposure pathway they break. The barriers are not equal in their ability to block an exposure pathway. Multiple barriers may be required to assure sustainable protection for current and future receptors.

4.1.1. Hazard Area Description

The ten contaminant release areas included in Hazard Area 1 are described below.

General Services Area (GSA) – Solvents containing VOCs were commonly used as degreasing agents in craft shops in the GSA. In the 1960s and 1970s, rinsewater from these operations was disposed in dry wells and VOC-contaminated debris was buried in trenches. Ground water cleanup began in 1991 and soil vapor extraction started in 1994. A Final ROD for this operable unit was signed in 1997. Ground water and soil vapor extraction have been very successful in decreasing the concentration and mass of subsurface contaminants and in reducing the offsite extent of contamination.

Building 834 – Spills and piping leaks at the Building 834 Complex from the early 1960s to the mid-1980s resulted in contamination of the subsurface with VOCs and silicone oils. Nitrate contamination in ground water results from septic-system effluent but may also have natural sources. Remedial activities performed at Building 834 include excavating VOC-contaminated soil in 1983 and installing a surface water drainage diversion system in 1998 to prevent rainwater infiltration in the contaminant source area. Ground water and soil vapor extraction and treatment have been underway since 1995 and have significantly reduced the concentration and volume of contaminants in the subsurface. An area-specific Interim ROD was signed in 1995 that was superceded by the Interim Site-Wide ROD. Significant *in situ* bioremediation is occurring. The selected interim remedy for Building 834 includes continued ground water and soil vapor extraction and treatment using an expanded well field.

High Explosives Process Area – Surface spills from 1958 to 1986 resulted in the release of VOCs at the drum storage and dispensing area for the former Building 815 steam plant. High-explosive compounds, nitrate, and perchlorate present in the subsurface are attributed to wastewater discharges to former unlined rinsewater lagoons from the 1950s to 1985. The High Explosives Burn Pits were capped under the Resource Conservation and Recovery Act (RCRA) in 1998. In 1999, DOE implemented a CERCLA removal action to perform ground water extraction at the Site boundary to prevent the TCE plume from migrating offsite. The selected interim remedy for the High Explosives Process Area includes continued ground water extraction and treatment, and no further action for VOCs and high-explosive compounds in the vadose zone.

Building 850 Firing Table – High-explosives experiments have been conducted at the Building 850 Firing Table since 1958. Tritium was used in these experiments, primarily between 1963 and 1978. As a result of the dispersal of test assembly debris during detonations, surface soil was contaminated with metals, PCBs, dioxins, furans, HMX, and depleted uranium.

Leaching from firing table debris has resulted in tritium and depleted uranium contamination in subsurface soil and ground water. Nitrate has also been identified in ground water. Gravel was removed from the firing table in 1988 and placed in the Pit 7 Landfill. PCB-contaminated shrapnel and debris was removed from the area around the firing table in 1998. The selected remedy for the Building 850 area includes excavation of the contaminated surface soil and a nearby sand pile as a final remedy and monitored natural attenuation of tritium in ground water as an interim remedy.

Building 854 – TCE was released to soil and ground water through leaks and discharges of heat-exchange fluid, primarily between 1967 and 1984. Other contaminants in ground water include nitrate and perchlorate. TCE-contaminated soil was excavated at the northeast corner of Building 854F in 1983. The selected interim remedy for Building 854 includes ground water and soil vapor extraction and treatment, and no further action for metals, high-explosive compounds, PCBs, and tritium in surface soil.

Building 832 Canyon – TCE was released to soil and ground water through leaks and discharges of heat-exchange fluid at Buildings 830 and 832 between the late 1950s and 1985. Nitrate and perchlorate are also present in ground water. The selected interim remedy for Buildings 830 and 832 includes continued soil vapor and ground water extraction and treatment, and no further action for high-explosive compounds in surface soil and nitrate in the vadose zone.

Building 801 Dry Well – Waste fluid was discharged to a dry well located adjacent to Building 801D from the late 1950s to 1984, resulting in minor subsurface VOC contamination. The dry well was decommissioned and filled with concrete in 1984. The selected interim remedy for Building 801 is continued ground water monitoring.

Building 833 - TCE was used as a heat-exchange fluid in the Building 833 area from 1959 to 1982 and was released through spills and rinsewater disposal, resulting in minor VOC contamination of the shallow soil/bedrock and perched ground water. The selected interim remedy for Building 833 is continued ground water monitoring.

Building 845 Firing Table – High-explosives experiments were conducted at the Building 845 Firing Table from 1958 to 1963. Leaching from firing table debris resulted in minor contamination of subsurface soil with depleted uranium and HMX. No ground water contamination has been detected. In 1988, firing table gravel and adjacent soil from the Building 845 Firing Table were removed and disposed in the Pit 1 Landfill. The selected interim remedy for Building 845 is continued ground water monitoring, and no further action for high-explosive compounds and depleted uranium in the vadose zone.

Building 851 Firing Table – The Building 851 Firing Table has been used for high-explosives research since 1982. These experiments resulted in minor VOC, depleted uranium, metals, and RDX contamination in soil and ground water. No unacceptable risk or hazard was identified in this area. In 1988, the firing table gravel was removed and has been replaced periodically since then. The selected interim remedy for Building 851 is continued ground water monitoring, and no further action for VOCs and depleted uranium in the vadose zone and high-explosive compounds and metals in surface soil.

4.1.2. Primary and Secondary Sources

Primary sources are locations where contaminants were produced, deposited, released, or disposed. The primary sources in Hazard Area 1 include:

- Discharges of contaminants to dry wells (sumps).
- Surface spills at facilities.
- Piping leaks.
- Infiltration from unlined high-explosive rinsewater lagoons.
- High-explosive test detonations.

Secondary sources are environmental media to which contaminants have migrated. Secondary sources in Hazard Area 1 include:

- Surface soil.
- Vadose zone soil and bedrock.
- Ground water.
- Surface water.
- Ambient indoor and outdoor air.

It is assumed that primary and secondary contaminant sources under the Current Cleanup Baseline End State and Risk-Based End State exposure scenarios are equivalent.

4.1.3. Release, Transport, and Exposure Mechanisms

The contaminant release, transport, and exposure mechanisms under the Current State, Current Baseline End State, and Risk-Based End State exposure scenarios are described below. Receptors are also identified.

4.1.3.1. Release Mechanisms

Release mechanisms are the manner in which contaminants migrate from a primary source to an environmental medium (secondary source). The only release mechanism in Hazard Area 1 at Site 300 is leakage or discharge of contaminants to surface soil or the vadose zone.

Volatilization of contaminants directly from the released contaminant is not applicable to the release sites in Hazard Area 1 because contaminants have already migrated into environmental media or directly-contaminated soil has been excavated. No active primary sources remain.

It is assumed that the release mechanisms under the Current Cleanup Baseline End State and Risk-Based End State exposure scenarios are equivalent.

4.1.3.2. Transport Mechanisms

Transport mechanisms describe the migration of contaminants between environmental media. Potential transport mechanisms in Hazard Area 1 include:

- **Volatilization of contaminants from surface soil or the vadose zone to ambient indoor and outdoor air –** In Hazard Area 1, this mechanism is applicable where VOCs or tritium occur in near-surface soil.

- **Resuspension of contaminated soil particles to outdoor ambient air –** In some locations in Hazard Area 1, contaminants are present in surface soil at concentrations of concern for this exposure pathway.
- **Infiltration of contaminants from the vadose zone to ground water –** This transport mechanism is applicable at several contaminant release locations in Hazard Area 1.
- **Outflow from ground water to surface water –** This mechanism is applicable at several springs at Site 300 where contaminated ground water is the source of spring flow.

The following transport mechanisms are not applicable to Hazard Area 1:

- **Transport of contaminants by runoff from surface soil or the vadose zone to surface water –** There are no locations in Hazard Area 1 where surface water bodies are contaminated by runoff, or have the significant potential to become contaminated by this transport mechanism.
- **Transport of contaminants by recharge from surface water to ground water –** Except for the previously-mentioned springs, there are no contaminated surface water bodies in Hazard Area 1, nor does the potential exist for ground water to become contaminated by this transport mechanism. All surface water contamination is the result of the discharge of contaminated ground water to springs.

It is assumed that transport mechanisms under the Current Cleanup Baseline End State and Risk-Based End State exposure scenarios are equivalent to those described in the Current State exposure scenario.

4.1.3.3. Exposure Mechanisms and Receptors

Exposure mechanisms describe how contaminants move from contaminated environmental media to human or ecological receptors. Receptors are human or ecological species that are potentially exposed to, or adversely affected by, contaminants. In the baseline risk assessment, all potential exposure mechanisms and receptors were considered. Exposure mechanisms and receptors for which no unacceptable risk or hazard was identified in the baseline risk assessment are not discussed further. In Hazard Area 1, unacceptable risk or hazard was identified for the following exposure mechanisms and receptors:

- **Inhalation of volatile contaminants in indoor ambient air by onsite industrial workers –** Unacceptable onsite human carcinogenic risk and/or non-carcinogenic hazard have been identified at several release areas in Hazard Area 1 due to VOCs volatilizing from the subsurface. The offsite unrestricted land use exposure pathway is not complete because all contaminated soil occurs within the Site 300 boundary and potential transport to offsite receptors is insignificant. In the baseline risk assessment, risk and hazard were calculated for volatile contaminants in subsurface soil migrating upward through the floors of buildings into indoor ambient air and being inhaled by workers within the building. This assessment assumed that an onsite worker would spend 8 hours a day, 5 days a week, for 30 years within the buildings. An unacceptable risk or hazard was identified at:

  1. Building 834D – Cumulative risk 1×10^{-3}, hazard index 35.7, due to TCE and PCE. Under both the Current Cleanup Baseline End State and the Risk-Based End State,

this risk will be mitigated through active remediation (soil vapor extraction) and managed using institutional controls.

2. Building 854A – Cumulative risk 1×10^{-6}, due to six VOCs. No VOCs were detected in past ambient air samples, and risk was calculated using detection limits. Under both the Current Cleanup Baseline End State and the Risk-Based End State, this risk will be mitigated through active remediation (soil vapor extraction) and managed using institutional controls.
3. Building 854F – Cumulative risk 9×10^{-6}, due to TCE, chloroform, and other VOCs. Under both the Current Cleanup Baseline End State and the Risk-Based End State, this risk will be mitigated through active remediation (soil vapor extraction) and managed using institutional controls.
4. Building 830 – Cumulative risk 2×10^{-6}, due to TCE and vinyl chloride. Under both the Current Cleanup Baseline End State and the Risk-Based End State, this risk will be mitigated through active remediation (soil vapor extraction) and managed using institutional controls.
5. Building 832F – Cumulative risk 3×10^{-6}, due to dichloropropane. Under both the Current Cleanup Baseline End State and the Risk-Based End State, this risk will be mitigated through active remediation (soil vapor extraction) and managed using institutional controls.
6. Building 833 – Cumulative risk 1×10^{-6}, due to TCE and chloroform. Under both the Current Cleanup Baseline End State and the Risk-Based End State, this risk will be managed using institutional controls.
7. Building 875 – Cumulative risk of 1×10^{-5}, due to TCE, PCE, 1,1-dichloroethylene, benzene, chloroform, and methylene chloride. Following six years of remediation, the risk was recalculated in 2000 and determined to be less than 1×10^{-6}. Under both the Current Cleanup Baseline End State and the Risk-Based End State, this risk will continue to be mitigated through active remediation (soil vapor extraction) and managed using institutional controls.

- **Inhalation of volatile contaminants in outdoor ambient air by onsite industrial workers –** In the baseline risk assessment, risk and hazard were calculated for volatile contaminants in subsurface soil migrating upward into outdoor ambient air and being inhaled by onsite workers. This assessment assumed a worker would spend 8 hours a day, 5 days a week, for 30 years working in these areas. An unacceptable risk or hazard was identified at:

1. Building 834D – Cumulative risk 7×10^{-4}, hazard index 21.4, due to TCE and PCE. Under both the Current Cleanup Baseline End State and the Risk-Based End State, this risk will be mitigated through active remediation (soil vapor extraction) and managed using institutional controls.
2. Building 815 – Cumulative risk 5×10^{-6}, due to TCE and PCE. Under both the Current Cleanup Baseline End State and the Risk-Based End State, this risk will be managed using institutional controls.
3. Building 854F – Cumulative risk 1×10^{-5}, due to chloroform and 1,2-DCA. Under both the Current Cleanup Baseline End State and the Risk-Based End State, this risk

will be mitigated through active remediation (soil vapor extraction) and managed using institutional controls.

4. Building 830 – Cumulative risk 1×10^{-5}, due to chloroform, 1,2-DCA, and vinyl chloride. Under both the Current Cleanup Baseline End State and the Risk-Based End State, this risk will be mitigated through active remediation (soil vapor extraction) and managed using institutional controls.

- **Inhalation, ingestion, and dermal contact with contaminants in surface soil by onsite industrial workers –** Unacceptable risk has been identified for onsite workers at two locations in Hazard Area 1 due to PCBs, dioxins, and furans in surface soil. In the baseline risk assessment, risk and hazard were calculated for inhalation of resuspended particulates, incidental ingestion of surface soil, and direct dermal contact with contaminated surface soil. These estimates assumed an onsite worker would spend 8 hours a day, 5 days a week, for 30 years working near the contamination. An unacceptable risk was identified at:

1. Building 850 – Cumulative risk 5×10^{-3}, due to PCBs, dioxins, and furans. Under both the Current Cleanup Baseline End State and the Risk-Based End State, this risk will be mitigated through active remediation (excavation) and managed using institutional controls.

2. Building 855 – Cumulative risk 3×10^{-3}, due to PCBs, dioxins, and furans. Under both the Current Cleanup Baseline End State and the Risk-Based End State, this risk will be mitigated through active remediation (excavation) and managed using institutional controls.

- **Ingestion of contaminated ground water by offsite residential receptors –** Unacceptable future risks were identified at several existing offsite wells and hypothetical (i.e., not currently existing or planned) water-supply wells that could be installed at the Site 300 boundary. In the baseline risk assessment, an unacceptable risk (1×10^{-5}) was associated with the potential ingestion of ground water over a 30-year period from a hypothetical offsite well located at the Site 300 boundary downgradient from contamination in the High Explosives Process Area. The offsite water-supply well closest to this area is Gallo-1, located approximately 1,125 ft hydraulically cross-gradient from the TCE plume in the High Explosives Process Area. This well is owned by the Gallo Ranch and used only to water livestock.

  In the baseline risk assessment, an unacceptable risk (7×10^{-2}) was associated with the potential ingestion of ground water over a 30-year period from a hypothetical offsite well located at the Site 300 boundary nearest to the Building 875 dry well release site in the central General Services Area. An unacceptable risk (5×10^{-5}) was also associated with the potential ingestion of ground water over a 30-year period from a hypothetical offsite well located at the Site 300 boundary nearest to the eastern General Services Area debris burial trench release site. In addition, the risks associated with potential use of contaminated ground water at two offsite water-supply wells, CDF-1 and SR-1, were 1×10^{-5} and 2×10^{-5}, respectively. Well CDF-1 is located approximately 350 ft downgradient from the eastern General Services Area release site and 1,200 ft downgradient from the central General Services Area release site. Well SR-1 is located over two miles downgradient from the eastern and central General Services Area release sites.

Under both the Current Cleanup Baseline End State and the Risk-Based End State, this risk will be mitigated through active remediation (ground water extraction).

- **Ingestion of contaminated ground water by onsite industrial receptors –** Onsite water-supply well 20 is currently used to supply water to workers at Site 300 and is monitored regularly. VOCs have been sporadically detected in samples from this well at concentrations below the drinking water standard. LLNL plans to connect to the Hetch-Hetchy water-supply system in the near future and no additional water-supply wells are planned for Site 300. All other water-supply wells at Site 300 are used only as backup wells for fire suppression, or have been sealed and abandoned.

  Under the Current Cleanup Baseline End State, onsite ground water contamination will be remediated through ground water extraction or monitored natural attenuation, with the point of compliance being the impacted ground water body. Under the Risk-Based End State, onsite ground water contamination would be remediated to the extent necessary to protect offsite receptors, with the point of compliance being the site boundary. Remaining onsite contamination would be managed using institutional controls.

- **Inhalation of VOCs volatilizing from surface water by onsite industrial receptors –** Unacceptable risk or hazard has been identified at several springs in Hazard Area 1. In the baseline risk assessment, risk and hazard were calculated for contaminants in surface water volatilizing into the atmosphere and being inhaled by onsite workers. This assessment assumed an onsite worker would spend 8 hours a day, 5 days a week, for 30 years working near the contaminated surface water. An unacceptable risk or hazard was identified at:

  1. Spring 5 (High Explosives Process Area) – Cumulative risk 1×10^{-5}, due to 1,1-DCE and TCE. The flow from spring 5 is negligible and the spring is characterized by moist soil with wetland vegetation. In the baseline risk assessment, the concentration of VOCs in surface water from spring 5 was assumed to be equal to the maximum historical concentrations detected in nearby monitor well W-817-03A. Under the Current Cleanup Baseline End State this risk will be mitigated through active remediation (ground water extraction) and managed using institutional controls. Under the Risk-Based End State, onsite ground water contamination would be remediated to the extent necessary to protect offsite receptors, with the point of compliance being the site boundary. Remaining onsite contamination would be managed using institutional controls.
  2. Spring 3 (Building 832 Canyon) – Cumulative risk 6×10^{-5}, hazard index 2.3, due to TCE and PCE. Under the Current Cleanup Baseline End State this risk will be mitigated through active remediation (ground water extraction) and managed using institutional controls. Under the Risk-Based End State, onsite ground water contamination would be remediated to the extent necessary to protect offsite receptors, with the point of compliance being the site boundary. Remaining onsite contamination would be managed using institutional controls.

- **Inhalation of VOCs in Subsurface Burrow Air (Ecological) –** In the baseline ecological assessment, hazard (defined as a hazard index greater than 1) to species important at the individual level (referred to as "important" species), was identified for ground squirrel and kit fox associated with the inhalation of VOCs in burrow air in the Building 834 area (Table 2). Kit fox (a State and Federal endangered species) were used as a representative important fossorial (burrowing) vertebrate species. Risk and hazard management measures are in place to ensure individuals of important fossorial vertebrate species do not reside in the portions of the Building 834 area associated with a hazard index greater than 1 for kit fox. Risk management would continue under both the Current Cleanup Baseline End State and Risk-Based End State scenarios.
- **Ingestion and Inhalation of Cadmium, PCBs, Dioxins, and Furans in Surface Soil (Ecological) –** In the baseline ecological assessment, hazard was associated with the combined oral ingestion and inhalation of cadmium in the Building 834 area, and PCBs, dioxins, and furans in the Building 850 area (Table 2). Hazard was identified for ground squirrel, deer, and kit fox. Kit fox were used as a representative important fossorial vertebrate species. Ecological risk and hazard management measures are in place to ensure individuals of important fossorial vertebrate species do not reside in portions of the Building 834 and Building 850 areas associated with an hazard index greater than 1 for kit fox. Risk management would continue under both the Current Cleanup Baseline End State and Risk-Based End State scenarios.

4.1.4. Temporary Barriers or Controls

Temporary controls have been implemented at several contaminant release sites in Hazard Area 1, including:

- Access is restricted and controlled by fencing and a full-time security force.
- Building occupancy and land use are controlled by Site 300 management.
- Safety briefings that discuss access requirements and areas of contamination are required of personnel working at Site 300.
- New onsite water-supply wells are subject to environmental review.
- Operational Safety Plans are required for all construction activities.
- A wildlife biologist reviews proposals for land-disturbing activities and recommends ecological protection measures, if appropriate.

It is assumed that the temporary barriers and controls that would be implemented under the Current Cleanup Baseline and Risk-Based End State exposure scenarios are equivalent.

4.1.5. Remediation, Mitigation, and Other Intervention

The following sections describe the exposure barriers that would be implemented under the Current Cleanup Baseline End State and the Risk-Based End State scenarios. These barriers prevent or mitigate human or ecological exposure to contaminants. For each exposure barrier, the residual risk that would remain after remediation is complete is presented, and uncertainties or failure modes that could result in exposure are described. However, the Contingency Plan for Site 300 (Ferry et al., 2002) identifies situations where the cleanup may not proceed as anticipated, and includes response actions to address these occurrences, should they arise.

4.1.5.1. Exposure Barrier 1 – Soil Vapor Extraction

Soil vapor extraction has been implemented at four contaminant release sites in Hazard Area 1 to: (1) mitigate risk associated with inhalation of VOCs volatilizing from subsurface soil, and (2) protect ground water from potential or further degradation due to downward migration of contaminants from the vadose zone. Specifically, removing contaminants from the vadose zone by soil vapor extraction reduces risk due to:

- Inhalation of contaminated indoor and outdoor ambient air by onsite workers and special-status burrowing animals.
- Ingestion of onsite and offsite ground water. Protection of ground water leads to mitigation of risk to onsite and offsite receptors through a ground water exposure pathway.

Although cleanup standards for the vadose zone have not been established for most contaminant release sites in Hazard Area 1, the remedies were designed assuming:

- Human excess cancer risk must be managed or reduced to less than 10^{-6} and a noncarcinogenic hazard index of 1 under an onsite industrial worker exposure scenario.
- Ecological hazards to special-status burrowing species must be managed or reduced to a hazard index of 1.
- Vadose zone contaminants must be reduced to concentrations such that leaching of contaminants does not impact onsite ground water at concentrations exceeding MCLs.

Under the Current Cleanup Baseline End State scenario, onsite soil vapor extraction would be continued until: (1) the cancer risk associated with the inhalation of VOCs volatilizing from subsurface soil by onsite workers is reduced to less than 10^{-6} and a noncarcinogenic hazard index of 1, and (2) vadose zone concentrations protective of onsite and offsite ground water are achieved. There is no offsite vadose zone contamination that presents an unacceptable risk to offsite receptors. The time or cost remaining to achieve this objective has not been determined.

Under the Risk-Based End State scenario, onsite soil vapor extraction would be continued until the inhalation risk to onsite workers is mitigated and concentrations protective of offsite ground water are achieved. The time or cost remaining to achieve this objective has not been determined.

The residual risk under the Current Cleanup Baseline End State and the Risk-Based End State will be below 10^{-6}, achieved either by active remediation or institutional controls.

Uncertainties or failure modes for this exposure barrier include:

- Changing subsurface conditions (e.g., unanticipated influx of moisture to the subsurface) could reduce the efficiency of soil vapor extraction or mobilize contaminants.
- Soil vapor extraction may not adequately remove contaminants from the vadose zone to the extent necessary to protect ground water from further degradation in a reasonable timeframe.

These uncertainties/failure modes apply to both the Current Cleanup Baseline and Risk-Based End States.

4.1.5.2. Exposure Barrier 2 – Ground Water Extraction

Ground water extraction has been implemented in 13 areas in Hazard Area 1. Specifically, removing contaminants from ground water by extraction reduces risk due to:

- Ingestion of ground water by onsite and offsite human receptors.
- Inhalation of VOCs by onsite human (industrial) receptors where contaminated ground water discharges at springs.

Although cleanup standards for ground water have not been established for most contaminant release sites in Hazard Area 1, the remedies were designed assuming that concentrations consistent with unrestricted land use must be achieved both onsite and offsite (at least as protective as MCLs).

Under the Current Baseline End State scenario, ground water extraction would be continued until concentrations consistent with unrestricted use are achieved both onsite and offsite. The point of compliance is the impacted ground water body. There will be no unacceptable residual risk to all identified receptors if land use remains as anticipated.

Under the Risk-Based End State scenario, ground water extraction would be limited to ensuring that MCLs (or lower) are achieved and maintained offsite. The point of compliance would be the site boundary. For ingestion of ground water, there would be no unacceptable residual risk to all identified receptors if land use remains as anticipated. A residual risk would remain for inhalation of VOCs by onsite workers at springs but has not been quantified.

Uncertainties or failure modes for this exposure barrier include:

- Changing subsurface conditions (e.g., unanticipated recharge) affect the effectiveness of ground water extraction.
- Ground water extraction may not adequately remove contaminants to the extent required to achieve cleanup standards, or protect offsite receptors, in a reasonable timeframe.
- Changes in ground water use, including installation of water-supply wells adjacent to Site 300. In addition to being receptor points for human consumption of ground water, offsite wells could alter ground water flow patterns and result in unanticipated contaminant migration toward the wells.

These uncertainties/failure modes apply to both the Current Cleanup Baseline and Risk-Based End States.

4.1.5.3. Exposure Barrier 3 – Monitored Natural Attenuation

Monitored natural attenuation has been implemented at one contaminant release site in Hazard Area 1 (tritium at Building 850). The risk reduction achieved through monitored natural attenuation is equivalent to that previously described for ground water extraction.

Under both the Current Cleanup Baseline End State and Risk-Based End State scenarios, monitored natural attenuation may be implemented at additional areas in a manner consistent with existing regulations and guidelines. However, the point of compliance for the Current Cleanup Baseline End State is the impacted ground water body. Under the Risk-Based End State the point of compliance would be the site boundary. There would be no unacceptable residual risk to all identified receptors if land use remains as anticipated.

Uncertainties or failure modes for this exposure barrier include:

- Changing subsurface conditions (e.g., unanticipated recharge) affect the effectiveness of monitored natural attenuation.
- Natural attenuation may not adequately degrade contaminants to the extent required to achieve cleanup standards, or protect offsite receptors, in a reasonable timeframe.
- Degradation could result in the formation of daughter products more toxic, persistent, or mobile than the original contaminant.
- Changes in ground water use, including installation of water-supply wells adjacent to Site 300. In addition to being receptor points for human consumption of ground water, offsite wells could alter ground water flow patterns and result in unanticipated contaminant migration toward the wells.

These uncertainties/failure modes apply to both the Current Cleanup Baseline and Risk-Based End States.

4.1.5.4. Exposure Barrier 4 – Soil Excavation

Soil excavation has been completed at several of the release sites in Hazard Area 1. Soil excavation reduces the potential and/or magnitude of risks resulting from exposure to primary source contamination and from leaching into the underlying vadose zone.

Under the Current Cleanup Baseline End State and Risk-Based End State scenarios, the excavation currently planned to mitigate risk from PCBs, dioxins, and furans in soil at Buildings 850 and 855 would be completed, but no additional excavation is anticipated. There would be no unacceptable residual risk to all identified receptors if land use remains as anticipated.

There are no identified uncertainties or failure modes associated with this exposure barrier.

4.1.5.5. Exposure Barrier 5 – Institutional Controls

Institutional controls protect human health by restricting access to or activities in areas of elevated risk or hazard (institutional controls), thereby preventing unacceptable exposure to contaminants during the remediation process. Engineering controls are implemented to mitigate exposure when institutional controls are not sufficient to manage exposure. The primary mechanism to implement many institutional controls at Site 300 is the Risk and Hazard Management Plan, contained within the Compliance Monitoring Plan/Contingency Plan for Interim Remedies at Site 300 (Ferry et al., 2002).

Institutional controls, such as onsite building access and local site use restrictions, are currently a component of many of the risk management actions at Site 300. Current building occupancy and site use restrictions will be maintained in areas identified to have an unacceptable risk or hazard until revised risk assessments show that the risk or hazard has been reduced to acceptable levels. Fencing and a full-time security force prevent access to Site 300 by unauthorized members of the public. Site 300 building occupancy and site use restrictions are necessary only to prevent exposure of onsite workers. These restrictions are implemented and maintained by Site 300 management. Currently, no Site 300 staff work full-time in any area or building where an unacceptable risk or hazard has been identified. Warning signs are posted in all areas and buildings where an unacceptable risk or hazard has been identified, stating that permanent occupancy of the facility (or area) on a full-time basis must be approved by the LLNL Hazards Control Department.

Under some circumstances, full-time building occupancy or local site use may be required in areas where and unacceptable risk or hazard has been identified. In these cases, engineering controls will be implemented to prevent unacceptable worker exposure to contaminants. Engineering controls may include installing a building ventilation system, paving an area to minimize volatilization of contaminants into the atmosphere, or requiring personal protective equipment while in the area. If construction or other temporary ground-disturbing activities become necessary in areas of soil contamination, controls such as wetting the soil to prevent resuspension of soil particles or the use of personal protective equipment will be implemented.

Other institutional controls include:

- Controlling water use from onsite water-supply wells to prevent human ingestion of potential contaminants.
- Monitoring for special-status burrowing species is performed where the hazard index exceeds 1.

It is assumed that these controls would be maintained under both the Current Cleanup Baseline End State and Risk-Based End State scenarios. There will be no unacceptable residual risk to all identified receptors if land use remains as anticipated.

Uncertainties or failure modes for this exposure barrier include:

- In the event of a transfer of ownership of the Site 300 to another entity, DOE would have to ensure that it met its responsibilities under Section 120 of CERCLA, which obligates DOE to clean up contamination resulting from DOE activities, or any future contamination resulting from DOE activities at the Site 300. In addition, no change of ownership of the site or any portion thereof could be performed by DOE without provision for continued maintenance of any containment system, treatment system, monitoring system, or other response action(s) installed or implemented.

This uncertainty/failure mode applies to both the Current Cleanup Baseline and Risk-Based End States.

4.2. Hazard Area 2 – Landfills

Hazard Area 2 is defined as the nine landfills located within the Site 300 boundary. Radioactive and hazardous waste from Site 300, LLNL Livermore Site, or Lawrence Berkeley National Laboratory operations was placed in these unlined landfills from the 1950s through the 1980s. Engineered caps have been placed on several of the landfills; other landfills are covered with non-engineered native soil. Releases from some of the landfills have resulted in soil and ground water contamination, primarily by VOCs, depleted uranium, and tritium. The landfills are grouped into a single Hazard Area due to similarities in:

- **Release Mechanism –** All releases resulted from leaching of contaminants from the buried debris to the underlying vadose zone and/or ground water. All the landfills are inactive.
- **Primary and Secondary Sources –** The environmental media affected are soil, bedrock, and ground water.

- **Release, Transport, and Exposure Mechanisms –** These factors are similar for all release areas in Hazard Area 2, and include surface and subsurface flow and transport, and ingestion, inhalation, and dermal exposure pathways.
- **Extent of Contamination –** Contamination from release areas in Hazard Area 2 is entirely contained within the Site 300 boundary.
- **Temporary Barriers or Controls –** All release areas in Hazard Area 2 share similar controls, such as measures to restrict access to landfills.
- **Remediation, Mitigation, and Other Interventions –** Several of the landfills have engineered caps, others are covered by non-engineered native soil.
- **Future Land Use –** All the landfills are located within the Site 300 boundary. It is assumed that DOE will maintain control of Site 300 for the foreseeable future.

The following characteristics of Hazard Area 2 are included in the Current State exposure scenario:

- Individual contaminant release areas.
- Primary and secondary sources.
- Release, transport, and exposure mechanisms, including receptors.
- Temporary barriers or controls.
- Remediation, mitigation, or other intervention.

The Current State and Risk-Based End State maps for Hazard Area 2 are presented as Figures 4.2a1 and 4.2b1, respectively. The Current State and Risk-Based End State Conceptual Site Model is shown on Figure 4.2a2,b2. On the Conceptual Site Model diagram, active pathways are shown as solid lines, blocked pathways are shown as dashed lines, and incomplete pathways are shown as dotted lines. Barriers are shown as heavy vertical or horizontal lines across the exposure pathway they break. The barriers are not equal in their ability to block an exposure pathway. Multiple barriers may be required to assure sustainable protection for current and future receptors.

4.2.1. Hazard Area Description

The nine landfills in Hazard Area 2 include:

Pit 1 Landfill – The Pit 1 Landfill was used until 1988 to dispose of debris and gravel from several firing tables at Site 300. The landfill was capped in 1992. RCRA Closure and Post-Closure documents have been approved and this facility is currently monitored under Waste Discharge Requirements issued by the State of California. No unacceptable risk or hazard to human health or ecological receptors has been associated with the Pit 1 Landfill, and there is no evidence of any release from the landfill.

Pit 2 Landfill – The Pit 2 Landfill was used from 1956 to 1960 to dispose of firing table debris and gravel from Buildings 801 and 802. Waste material was buried to depths of 6 to 8 ft and covered with locally-obtained soil. No unacceptable risk or hazard to human health or ecological receptors has been associated with the Pit 2 Landfill, and there is no evidence of any release from the landfill. The selected interim remedy for the Pit 2 Landfill is enhanced vadose zone and ground water monitoring to detect any future releases from the landfill.

Pit 6 Landfill – From 1964 to 1973, approximately 1,900 cubic yards of waste was buried in nine unlined trenches and animal pits at the Pit 6 Landfill. Contaminants in the subsurface include VOCs (primarily TCE), tritium, nitrate, and perchlorate. In 1971, DOE excavated portions of the waste contaminated with depleted uranium. In 1997, a landfill cap was installed as a CERCLA removal action to prevent infiltrating precipitation from further leaching contaminants from the waste. Because of decreasing TCE concentrations in ground water, the presence of TCE degradation products, and the short half-life of tritium (12.3 years), the selected interim remedy for TCE and tritium at the Pit 6 Landfill is monitored natural attenuation. During the period covered by the Interim Site-Wide ROD, DOE will continue evaluating the source, extent, and natural degradation of perchlorate and nitrate at the Pit 6 Landfill. The interim remedy for these substances in ground water is continued monitoring.

Pit 7 Landfill Complex – The Pit 3, 4, 5, and 7 Landfills are collectively designated the Pit 7 Landfill Complex. Firing table debris containing VOCs, tritium, depleted uranium, and metals was placed in the pits in the 1950s through the 1980s. The Pit 4 and 7 Landfills were capped in 1992. Ongoing release of tritium and depleted uranium to ground water is occurring. DOE is continuing to characterize the area and is preparing an area-specific Remedial Investigation/Feasibility Study. A remedy for the Pit 7 Landfill Complex will be incorporated into the Interim ROD by amendment.

Pit 8 Landfill – The Pit 8 Landfill was used to dispose of debris from the Building 801 Firing Table until an earthen cover was installed in 1974. The debris buried in the pit may contain tritium, uranium, and/or high-explosive compounds. However, there is no evidence of a contaminant release from the landfill. The selected interim remedy for the Pit 8 Landfill is enhanced vadose zone and ground water monitoring to detect any future releases from the landfill.

Pit 9 Landfill – The Pit 9 Landfill was used to dispose of firing table debris generated at the Building 845 Firing Table. The debris buried in the pit may contain tritium, uranium, and/or high-explosive compounds. However, there is no evidence of a contaminant release from the Pit 9 Landfill. The selected interim remedy for the Pit 9 Landfill is enhanced vadose zone and ground water monitoring to detect any future releases from the landfill.

Ground water monitoring systems are in place, or will be installed, at all landfills. In addition, vadose zone monitoring systems will be installed at the Pit 2, 8, and 9 Landfills. Formal monitoring programs are in place at all landfills.

4.2.2. Primary and Secondary Sources

Primary sources are locations where contaminants were produced, deposited, released, or disposed. The primary sources in Hazard Area 2 are the landfill debris.

Secondary sources are environmental media to which contaminants have migrated. Secondary sources in Hazard Area 2 include:

- Vadose zone soil and bedrock.
- Ground water.

It is assumed that primary and secondary contaminant sources under the Current Cleanup Baseline End State and Risk-Based End State exposure scenarios are equivalent.

4.2.3. Release, Transport, and Exposure Mechanisms

The contaminant release, transport, and exposure mechanisms under the Current State, Current Baseline End State, and Risk-Based End State exposure scenarios are described below. Receptors are also identified.

4.2.3.1. Release Mechanisms

The primary release mechanism for the landfills is leaching of contaminants in the landfill contents to the vadose zone. However, at the Pit 7 Landfill Complex, contaminants are also released directly to ground water when ground water rises into the landfills during periods of high precipitation.

It is assumed that the release mechanisms under the Current Cleanup Baseline End State and Risk-Based End State exposure scenarios are equivalent.

4.2.3.2. Transport Mechanisms

The primary transport mechanism at the landfills is infiltration of contaminants from the vadose zone to ground water. It is assumed that transport mechanisms under the Current Cleanup Baseline End State and Risk-Based End State exposure scenarios are equivalent to those described in the Current State exposure scenario.

4.2.3.3. Exposure Mechanisms and Receptors

In the baseline risk assessment, all potential exposure mechanisms and receptors were considered. Exposure mechanisms and receptors for which no unacceptable risk or hazard was identified in the baseline risk assessment are not discussed further. In Hazard Area 2, unacceptable risk or hazard was identified for the following exposure mechanisms and receptors:

- **Inhalation of VOCs volatilizing from subsurface soil to outdoor ambient air –** In the baseline risk assessment, risk and hazard were calculated for volatile contaminants in subsurface soil migrating upward into outdoor ambient air and being inhaled by onsite workers. This assessment assumed a worker would spend 8 hours a day, 5 days a week, for 30 years working in these areas. An unacceptable inhalation risk of 5×10^{-6} was identified for onsite industrial receptors at the Pit 6 Landfill due to multiple VOCs. Although an unacceptable risk was identified in the baseline risk assessment, an engineered cap was later placed over the Pit 6 Landfill that includes an impermeable geomembrane layer covering the entire landfill area that prevents VOC vapors from reaching outdoor ambient air where workers could be exposed. No further risk management measures to prevent inhalation of VOCs are needed.
- **Inhalation of VOCs volatilizing from surface water to outdoor ambient air –** In the baseline risk assessment, risk and hazard were calculated for contaminants in surface water volatilizing into the atmosphere and being inhaled by onsite workers. This assessment assumed an onsite worker would spend 8 hours a day, 5 days a week, for 30 years working near the contaminated surface water. An unacceptable risk or hazard was identified at:

    1. Spring 7 (southeast of the Pit 6 Landfill) – Cumulative risk 4×10^{-5}, hazard index 1.1, due to TCE, PCE 1,2-DCA, and chloroform. Spring 7 flows at the ground surface only during extremely wet years. Under both the Current Cleanup Baseline End State

and the Risk-Based End State, this risk would be remediated using monitored natural attenuation and managed using institutional controls.

2. The Carnegie State Vehicular Recreation Area pond (east of the Pit 6 Landfill) – Cumulative risk 2×10^{-6}, due to TCE. At the recreation area, water-supply well CARNRW-2 is used to fill a pond, but the water is not subsequently used by the recreation area staff and visitors. The baseline risk assessment indicated that if the VOC source in the Pit 6 Landfill was not controlled, contaminated ground water could migrate to well CARNRW-2 and result in an unacceptable risk from inhaling VOC vapors volatilizing from the pond. Although an unacceptable risk was identified in the baseline risk assessment, an engineered cap was later placed over the Pit 6 Landfill that included an impermeable geomembrane layer that prevents infiltration of precipitation and further releases of contaminants from the landfill. No VOCs have been detected in the pond or in well CARNRW-2. Under both the Current Cleanup Baseline End State and the Risk-Based End State, this risk would be remediated using monitored natural attenuation and managed using institutional controls.

- **Inhalation of VOCs in Subsurface Burrow Air (Ecological) –** In the baseline ecological assessment, hazard (defined as a hazard index greater than 1) to species important at the individual level (referred to as "important" species), was identified for ground squirrel and kit fox associated with the inhalation of VOCs in burrow air in the Pit 6 Landfill area (Table 2). Kit fox (a State and Federal endangered species) were used as a representative important fossorial (burrowing) vertebrate species. Risk and hazard management measures are in place to ensure individuals of important fossorial vertebrate species do not reside in the portions of the Pit 6 Landfill area associated with a hazard index greater than 1 for kit fox. Risk management would continue under both the Current Cleanup Baseline End State and Risk-Based End State scenarios.

4.2.4. Temporary Barriers or Controls

Temporary controls have been implemented at several contaminant release sites in Hazard Area 2, including:

- Access is restricted and controlled by fencing and a full-time security force.
- Building occupancy and land use are controlled by Site 300 management.
- Safety briefings that discuss access requirements and areas of contamination are required of personnel working at Site 300.
- New onsite water-supply wells are subject to environmental review.
- Operational Safety Plans are required for all construction activities.
- A wildlife biologist reviews proposals for land-disturbing activities and recommends ecological protection measures, if appropriate.
- Land-disturbing activities are not allowed at Site 300 landfills.
- Landfill subsidence monitoring and controls to prevent damage to the landfill caps and covers.

It is assumed that the temporary barriers and controls that would be implemented under the Current Cleanup Baseline and Risk-Based End State exposure scenarios are equivalent.

4.2.5. Remediation, Mitigation, and Other Intervention

The following sections describe the exposure barriers that would be implemented under the Current Cleanup Baseline End State and the Risk-Based End State scenarios. These barriers prevent or mitigate human or ecological exposure to contaminants. For each exposure barrier, the residual risk that would remain after remediation is complete is presented, and uncertainties or failure modes that could result in exposure are described. However, the Contingency Plan for the Site 300 Site (Ferry et al., 2002) identifies situations where the cleanup may not proceed as anticipated, and includes response actions to address these occurrences, should they arise.

Ground water monitoring systems are in place, or will be installed, at all landfills. In addition, vadose zone monitoring systems will be installed at the Pit 2, 8, and 9 Landfills. Formal monitoring programs are in place at all landfills.

4.2.5.1. Exposure Barrier 1 – Landfill Caps and Covers

An engineered cap was placed over the Pit 6 Landfill that includes an impermeable geomembrane layer covering the entire landfill area that prevents: (1) VOC vapors from reaching outdoor ambient air where workers could be exposed, (2) infiltration of precipitation and resultant mobilization/leaching of contaminants in the landfill debris, and (3) direct contact with the landfill contents. Although no inhalation risk has been identified at the Pits 1, 4 and 7 landfills, engineered caps prevent infiltration of precipitation and resultant mobilization/leaching of contaminants in the landfill debris and direct contact with the landfill contents. Additional controls to prevent impacts to ground water are being evaluated in the Remedial Investigation/Feasibility Study for the Pit 7 Complex.

Under both the Current Cleanup Baseline End State and Risk-Based End State scenarios, these caps would be monitored and maintained for as long as the waste remains a potential threat to receptors or to ground water quality. There would be no unacceptable residual risk to all identified receptors if land use remains as anticipated.

Uncertainties or failure modes for this exposure barrier include:

- Unidentified breaching or damage to the landfill surface could result in exposure to the landfill contents or allow precipitation or surface water to enter the landfill, mobilizing contaminants from the landfill debris.
- Ensuring the performance of long-term monitoring and maintenance.

These uncertainties/failure modes apply to both the Current Cleanup Baseline and Risk-Based End States.

4.2.5.2. Exposure Barrier 2 – Ground and Surface Water Control

Ground and surface water controls have been implemented or planned for several landfills. These controls are designed to prevent water from infiltrating through the landfill caps/covers and to prevent ground water from rising into the landfills and subsequent mobilization of contaminants.

Under both the Current Cleanup Baseline End State and Risk-Based End State scenarios, these systems would be monitored and maintained for as long as the waste remains a potential threat to receptors or to ground water quality. There would be no unacceptable residual risk to all identified receptors if land use remains as anticipated.

Uncertainties or failure modes for this exposure barrier include:

- The ability of the ground and surface water control systems to adequately prevent mobilization of contaminants from the landfill contents.
- Ensuring long-term maintenance of the systems.

These uncertainties/failure modes apply to both the Current Cleanup Baseline and Risk-Based End States.

4.2.5.3. Exposure Barrier 3 – Monitored Natural Attenuation

A monitored natural attenuation remedy has been implemented for TCE at the Pit 6 Landfill under the Current State exposure scenario.

Under both the Current Cleanup Baseline End State and Risk-Based End State scenarios, monitored natural attenuation may be implemented at additional areas in a manner consistent with existing regulations and guidelines. However, the point of compliance for the Current Cleanup Baseline End State is the impacted ground water body. Under the Risk-Based End State the point of compliance would be the site boundary. There would be no unacceptable residual risk to all identified receptors if land use remains as anticipated.

Uncertainties or failure modes for this exposure barrier include:

- Changing subsurface conditions (e.g., unanticipated recharge) affect the effectiveness of monitored natural attenuation.
- Natural attenuation may not adequately degrade contaminants to the extent required to achieve cleanup standards, or protect offsite receptors, in a reasonable timeframe.
- Degradation could result in the formation of daughter products more toxic, persistent, or mobile than the original contaminant.
- Changes in ground water use, including installation of water-supply wells adjacent to Site 300. In addition to being receptor points for human consumption of ground water, offsite wells could alter ground water flow patterns and result in unanticipated contaminant migration toward the wells.

These uncertainties/failure modes apply to both the Current Cleanup Baseline and Risk-Based End States.

4.2.5.4. Exposure Barrier 4 – Institutional Controls

In addition to the institutional controls described for Hazard Area 1 (Section 4.1.5.5) the following controls are applicable to the landfills at Site 300:

- The LLNL Environmental Restoration Division coordinates with Site 300 management to ensure that no excavation occurs in areas of contamination or at landfills except for approved remedial actions or under the supervision of the LLNL Hazards Control Department. Activities in landfill areas are restricted to those that will not expose landfill material or compromise the integrity of the landfill surfaces.

- Monitoring for special-status burrowing species is performed where the hazard index exceeds 1.

It is assumed that these controls would be maintained under both the Current Cleanup Baseline End State and Risk-Based End State scenarios. There will be no unacceptable residual risk to all identified receptors if land use remains as anticipated.

Uncertainties or failure modes for this exposure barrier include:

- In the event of a transfer of ownership of the Site 300 to another entity, DOE would have to ensure that it met its responsibilities under Section 120 of CERCLA, which obligates DOE to clean up contamination resulting from DOE activities, or any future contamination resulting from DOE activities at Site 300. In addition, no change of ownership of the site or any portion thereof could be performed by DOE without provision for continued maintenance of any containment system, treatment system, monitoring system, or other response action(s) installed or implemented.

This uncertainty/failure mode applies to both the Current Cleanup Baseline and Risk-Based End States.

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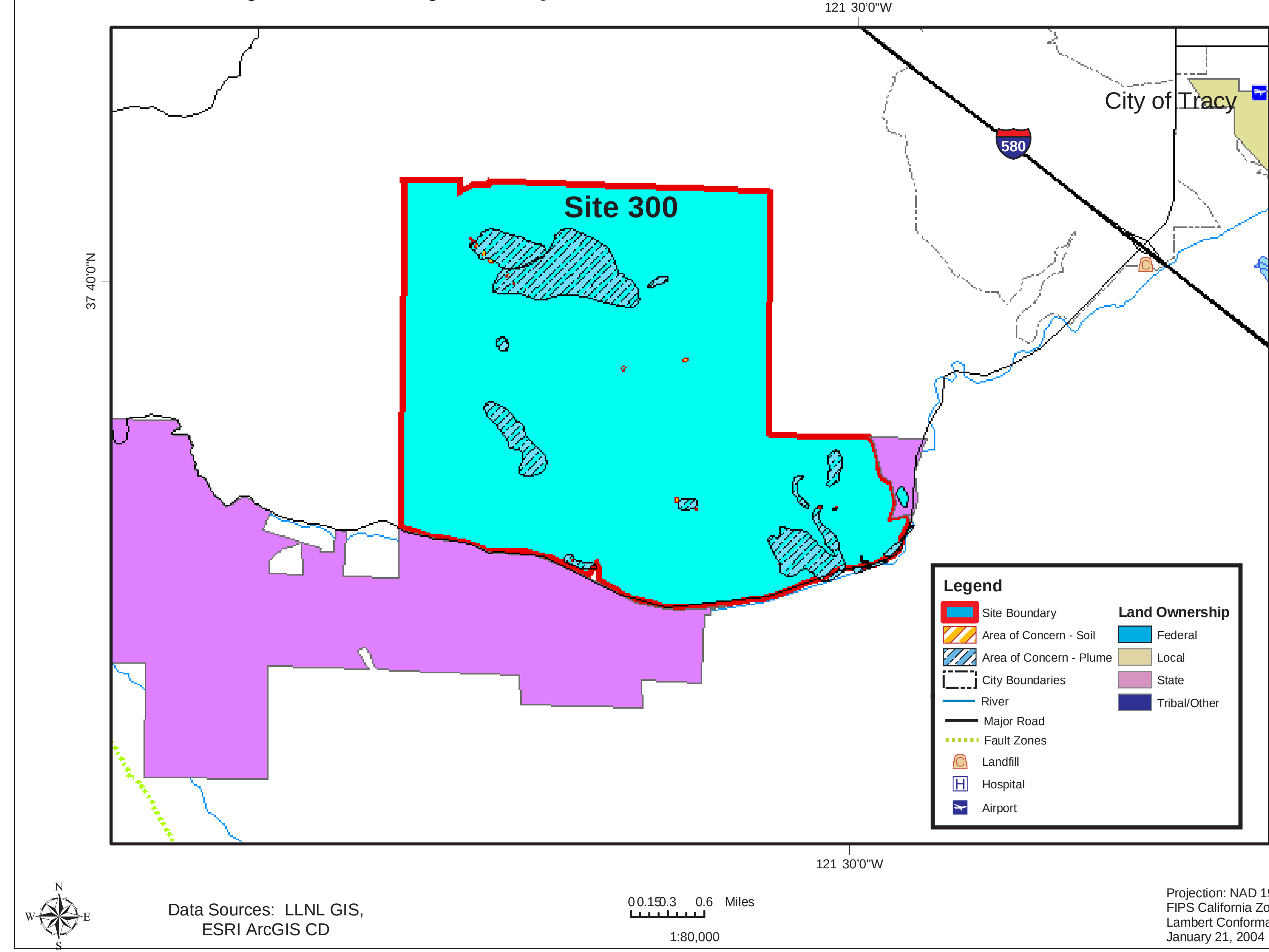
Figures

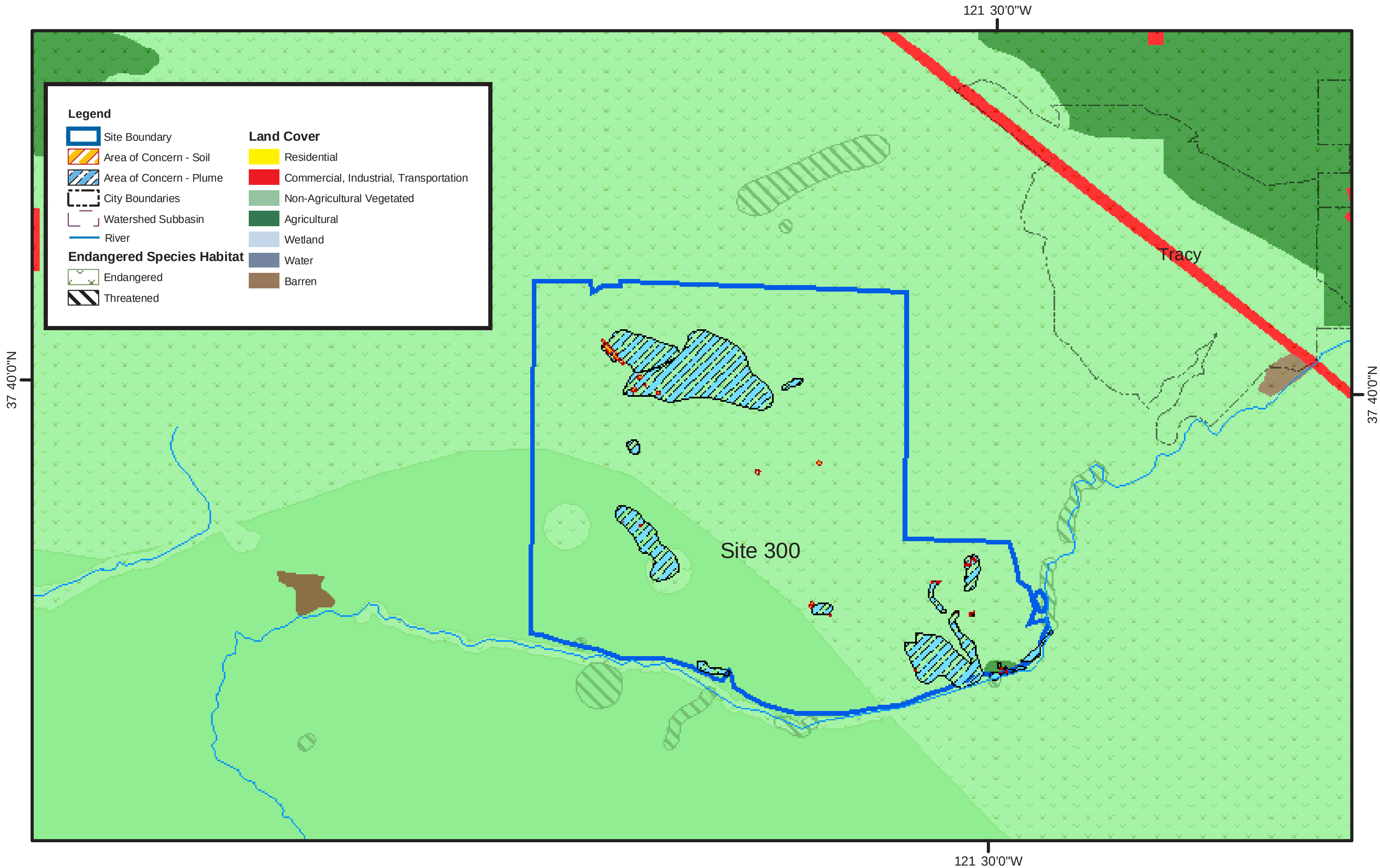
Figure 2.1a,b. Regional Physical and Surface Interface - Current State and RBES



Data Sources: LLNL GIS, ESRI ArcGIS CD

Projection: NAD 1983 State Plane
FIPS California Zone 0403
Lambert Conformal Conic
January 21, 2004

Figure 2.2a,b. Regional Human and Ecological Land Use - Current State and RBES



Data Sources: LLNL GIS,
ESRI ArcGIS CD

0 0.5 1 2 Miles

1:80,000

Projection: NAD 1983 State Plane
FIPS California Zone 0403
Lambert Conformal Conic
January 21, 2004

Figure 3.1a,b. Site Physical and Surface Interface - Current State and RBES

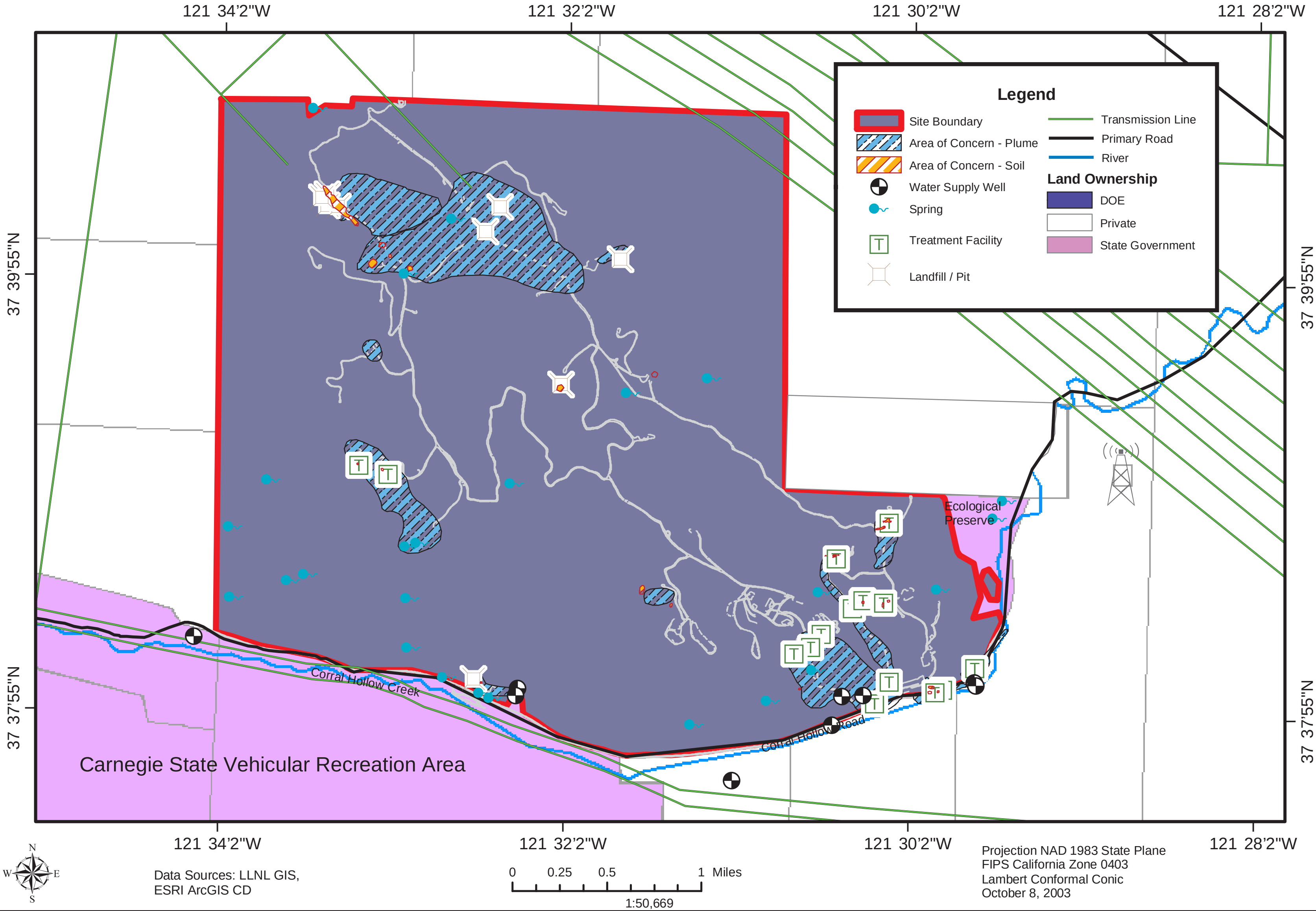


Figure 3.2a. Site Human and Ecological Land Use - Current State

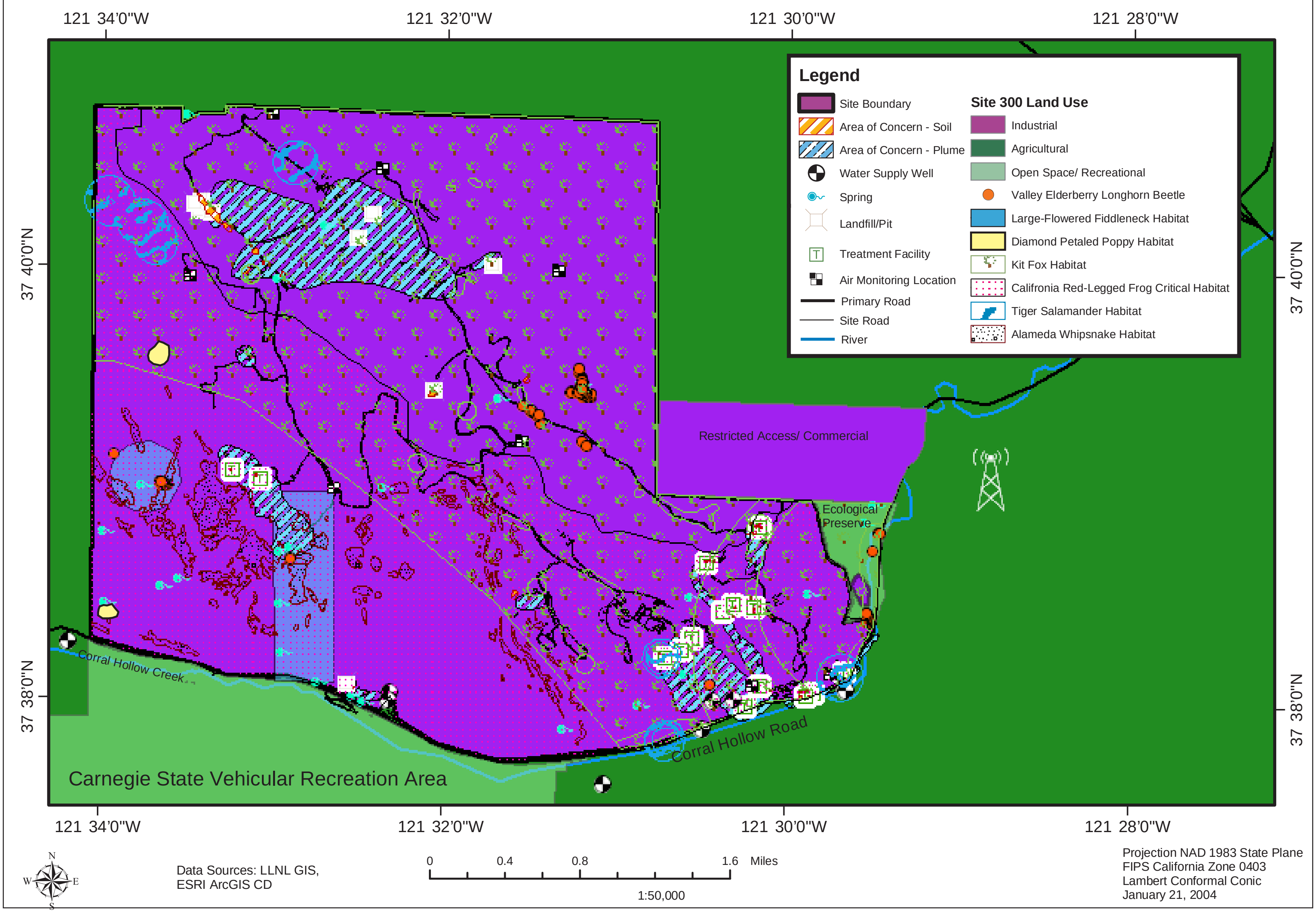


Figure 3.2b. Site Human and Ecological Land Use - RBES

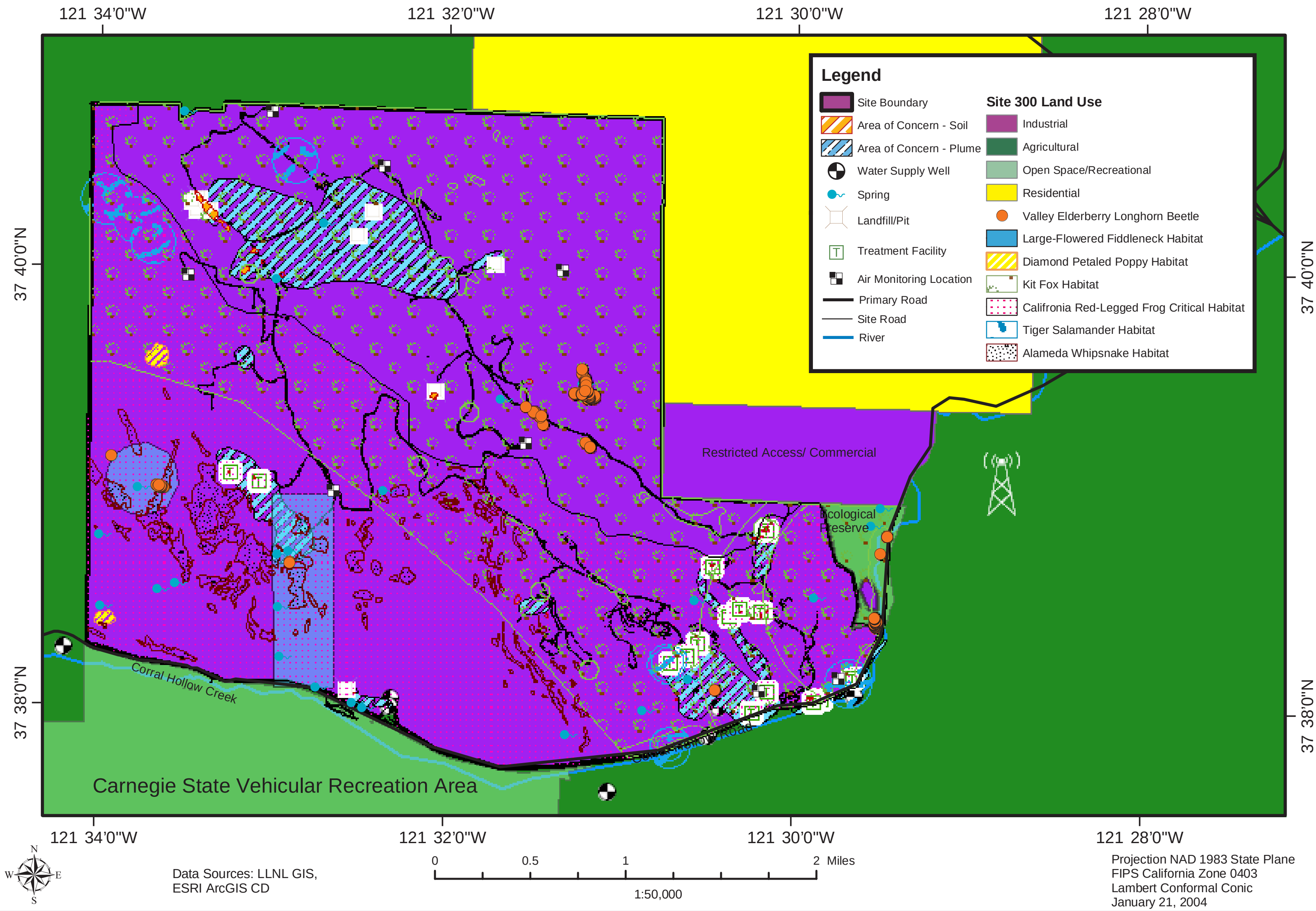
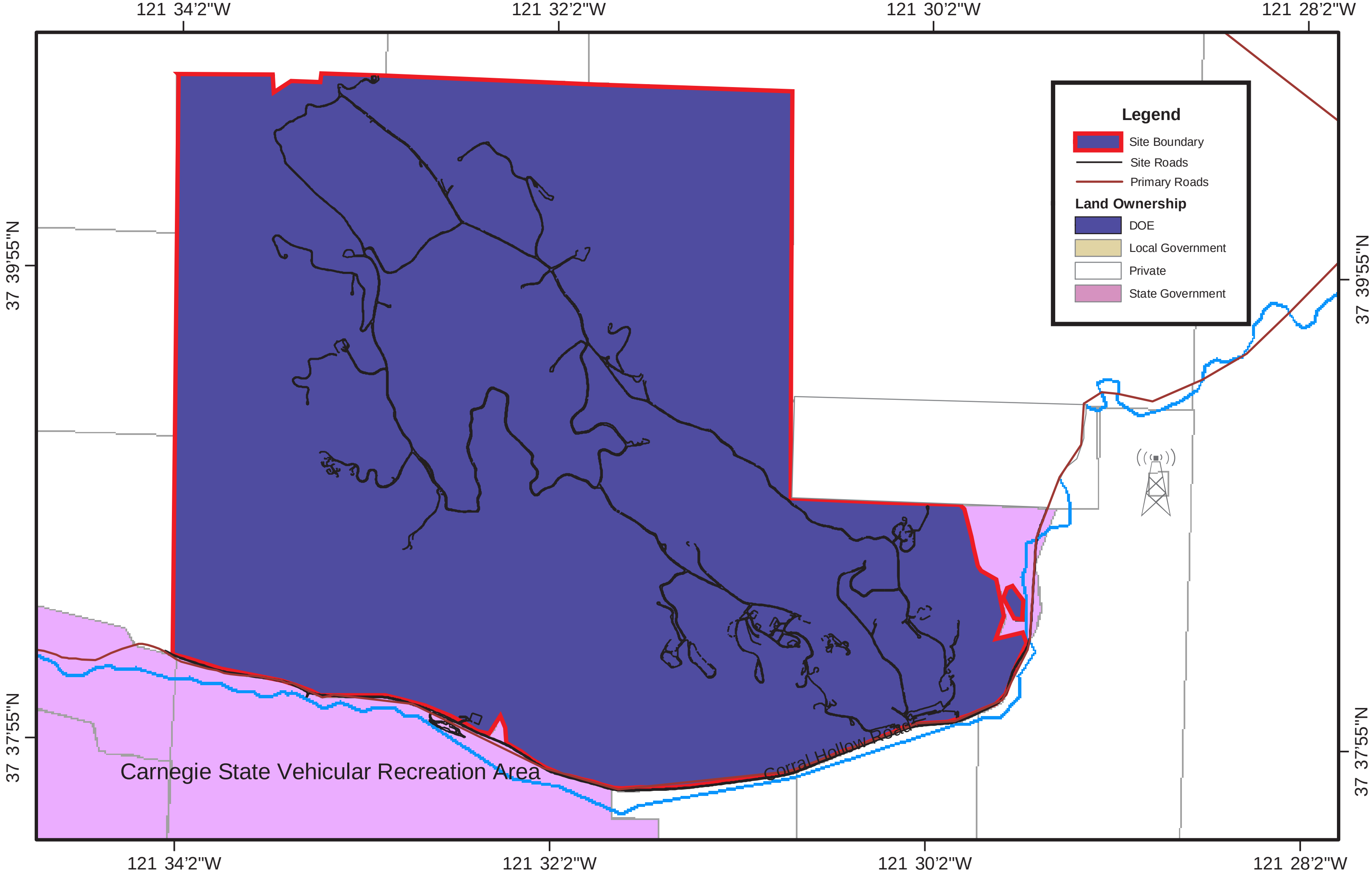


Figure 3.3a,b. Site Legal Ownership - Current State and RBES



Data Sources: LLNL GIS,
ESRI ArcGIS CD

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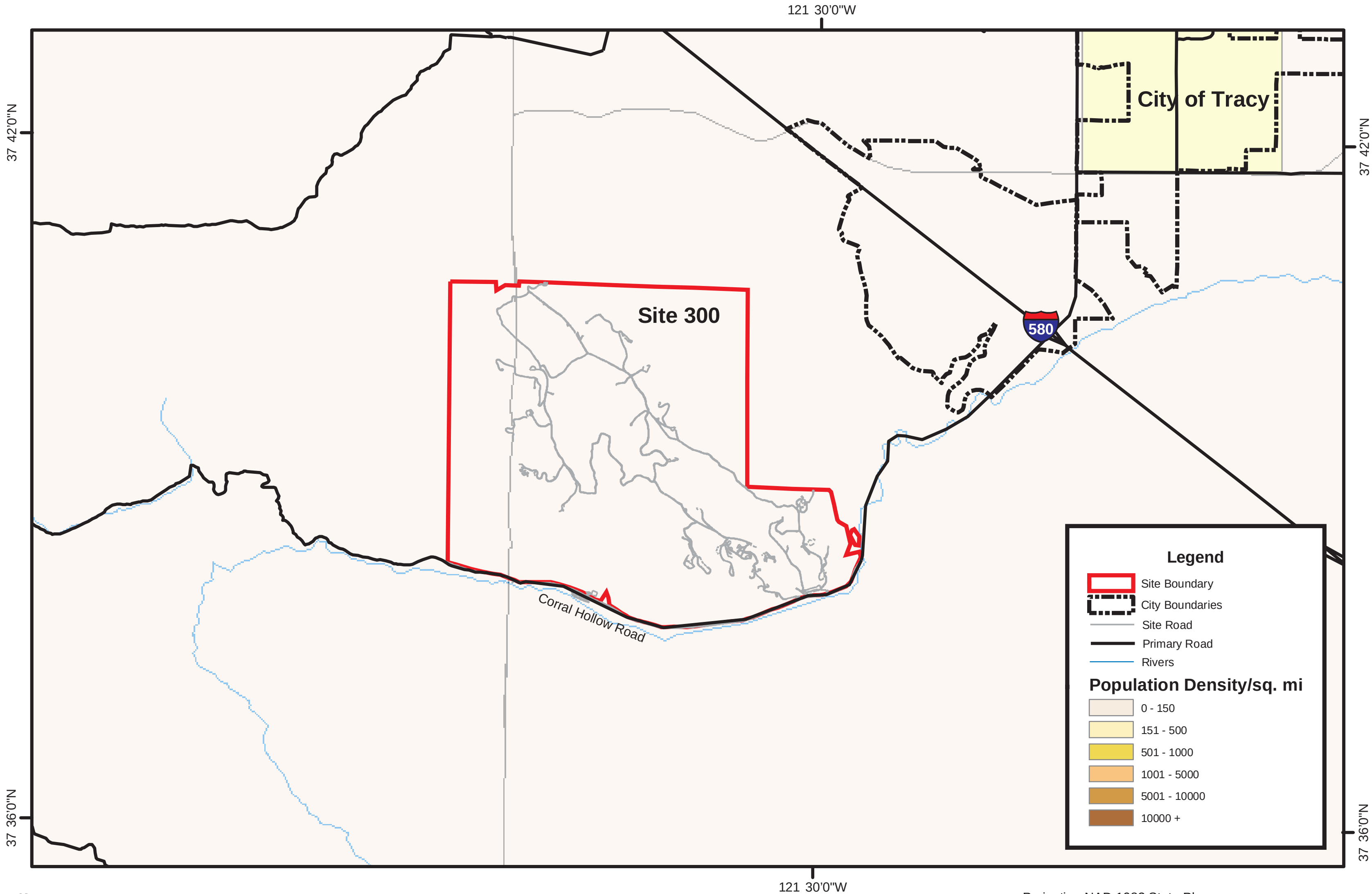
1:50,000

Projection NAD 1983 State Plane
FIPS California Zone 0403
Lambert Conformal Conic
January 21, 2004

Figure 3.4a,b. Site Demographics - Current State and RBES



N
W E
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Data Sources: LLNL GIS,
ESRI ArcGIS CD

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1:100,000

Projection NAD 1983 State Plane
FIPS California zone 0403
Lambert Conformal Conic
January 21, 2004

Figure 4.0a,b. Site-wide Hazard Map - Current State and RBES

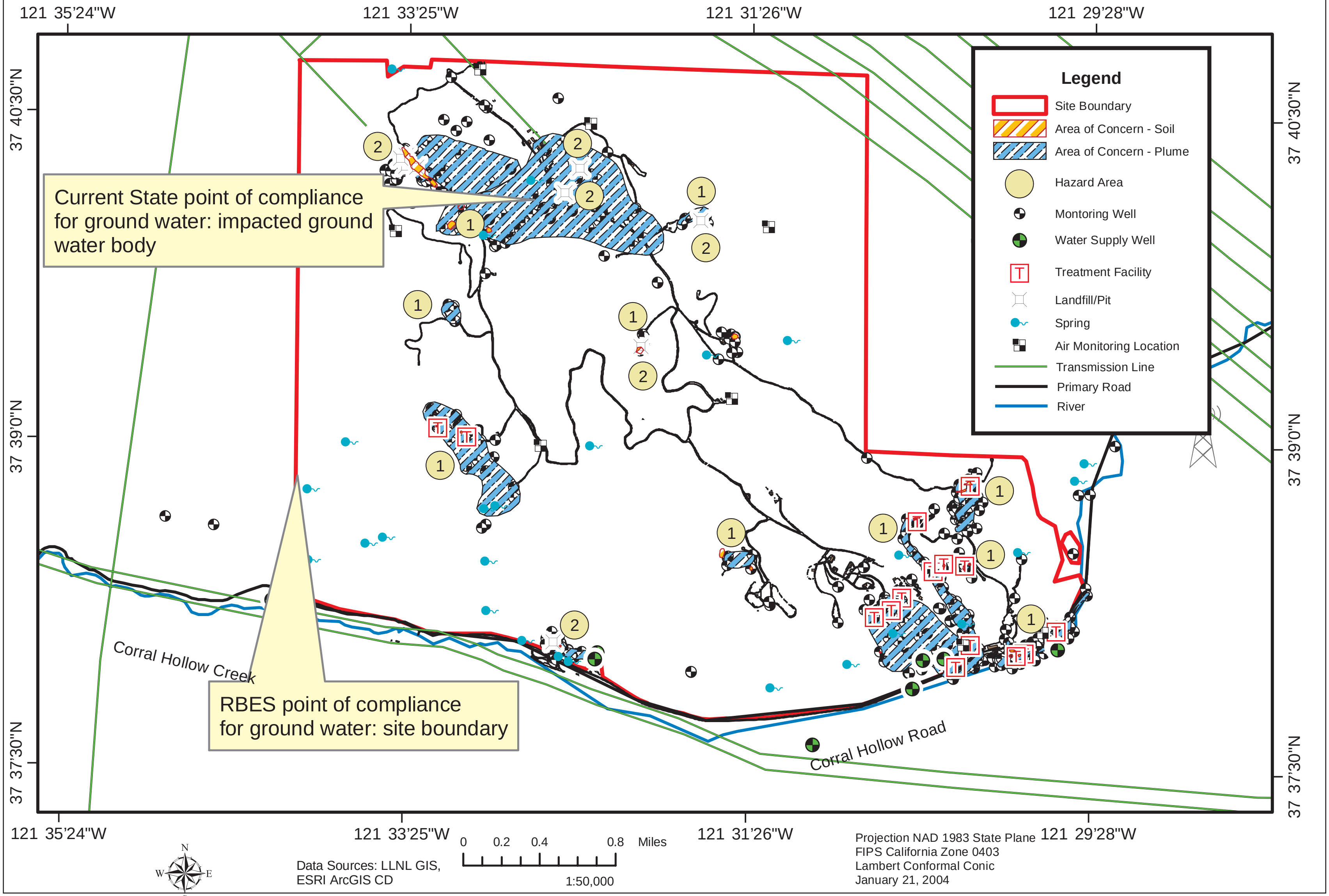


Figure 4.0a,b. (detail) Site-wide Hazard Map - Current State and RBES
Detail of SE portion of Site 300

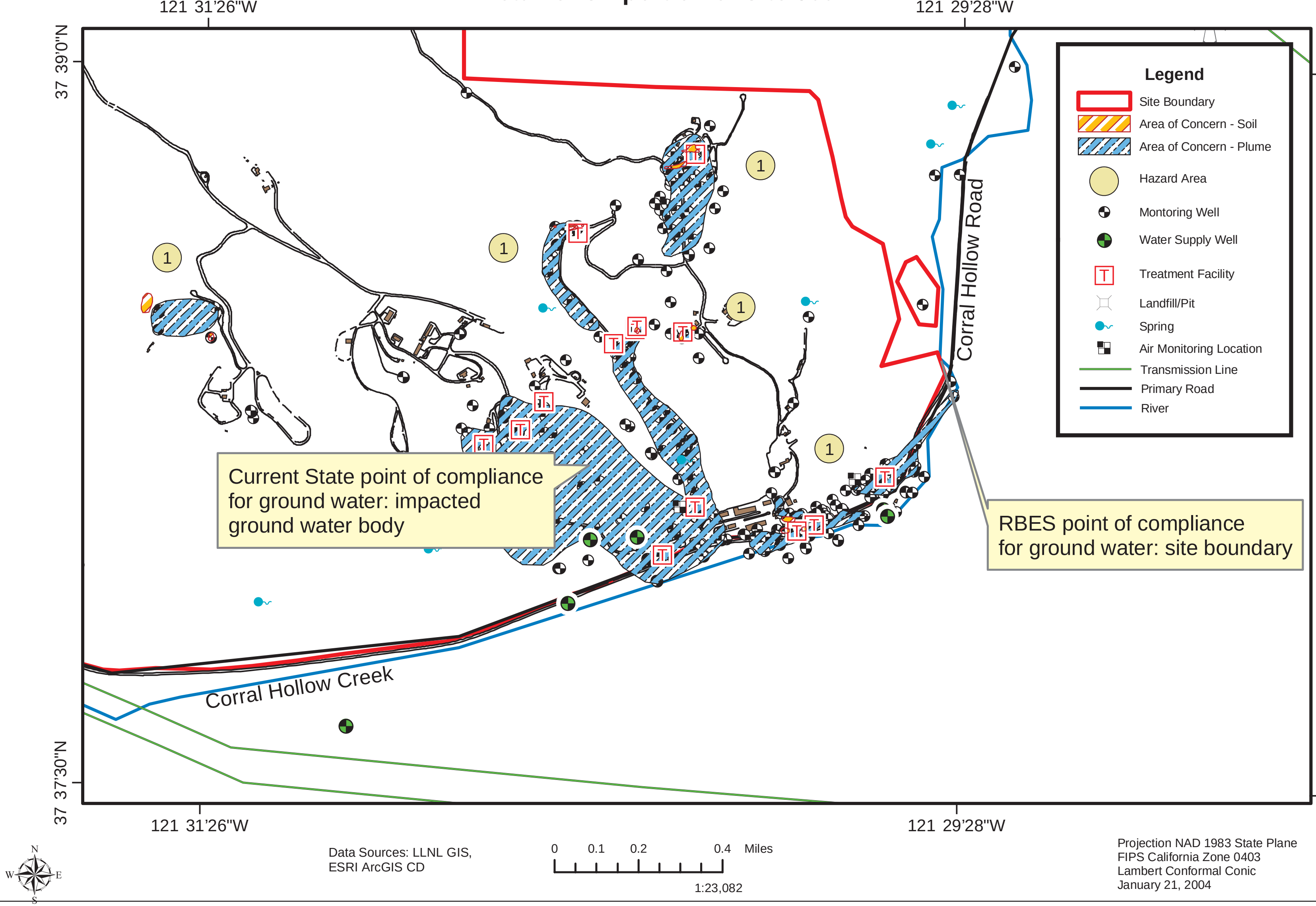
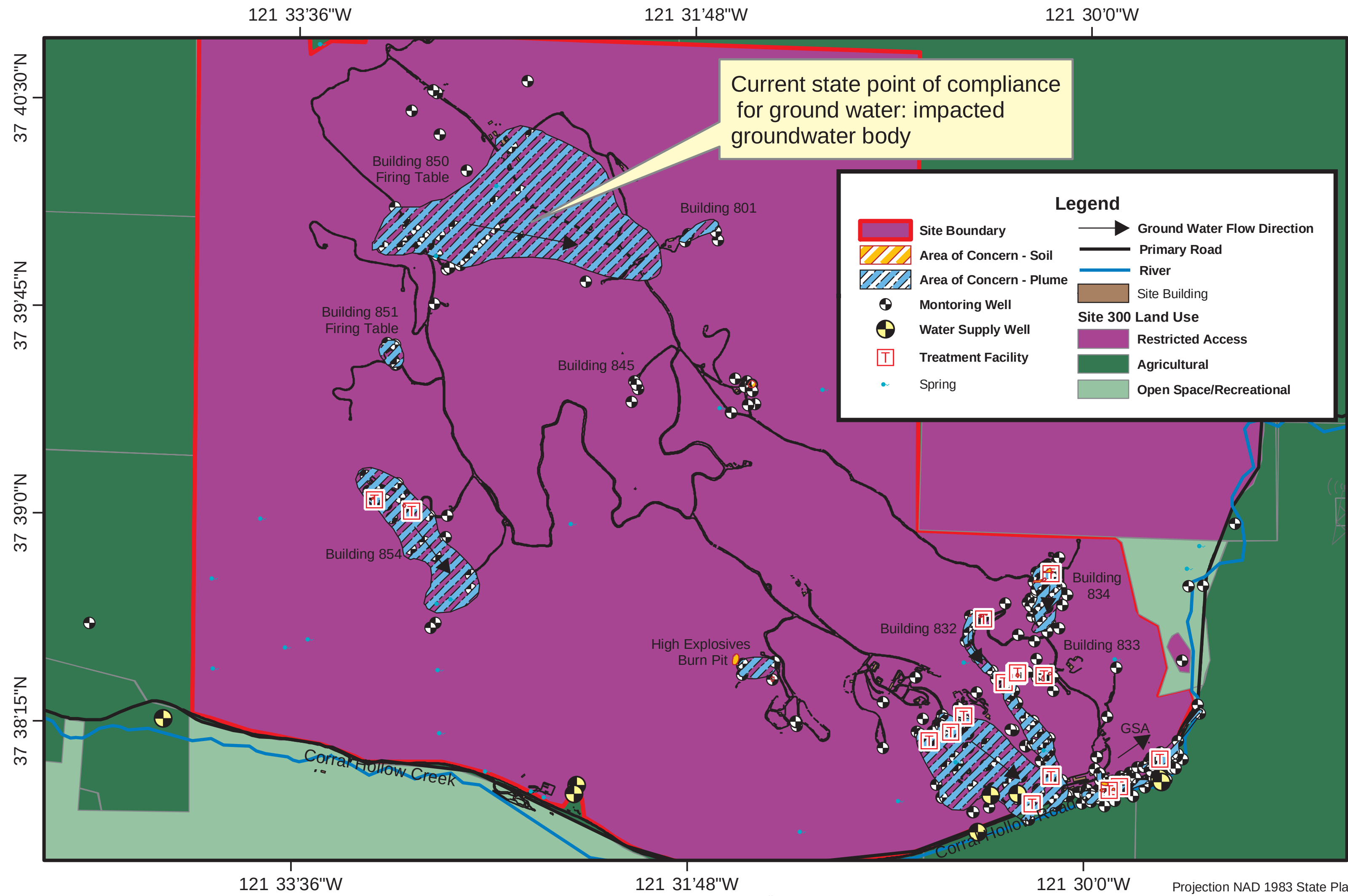


Figure 4.1a1. Hazard Area 1: Facility Contaminant Releases Map - Current State



Data Sources: LLNL GIS, ESRI ArcGIS CD

Projection NAD 1983 State Plane FIPS California Zone 0403 Lambert Conformal Conic January 21, 2004

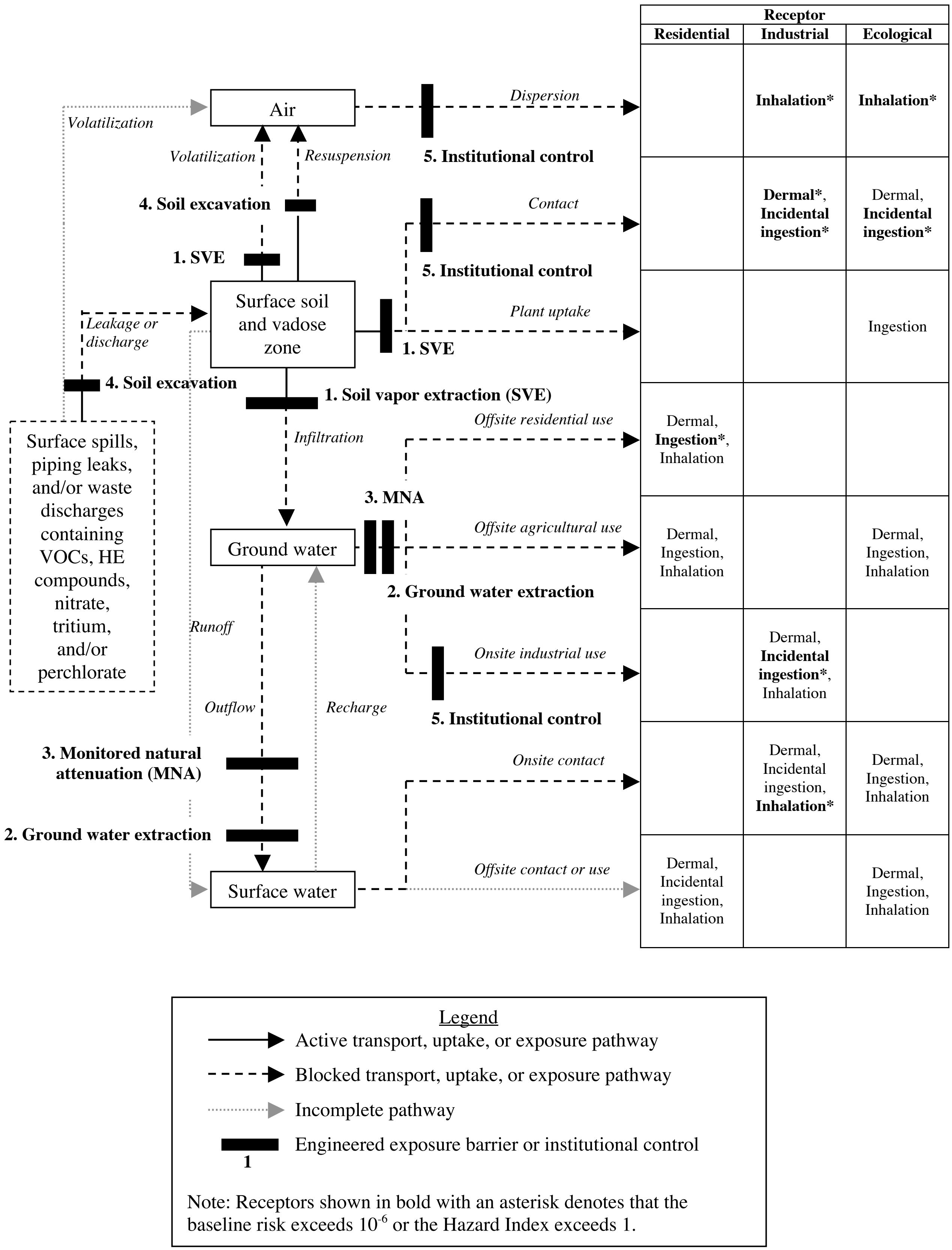


Figure 4.1a2,b2. Hazard Area 1: Facility Contaminant Releases CSM – Current State and RBES (page 1 of 6).

Narrative for Hazard Area 1 Current State and RBES Exposure Scenarios CSM (Figure 4.1a2,b2)

This narrative provides a summary of information presented in Section 4 of this Risk-Based End State Vision document. Because the only difference between the Current Cleanup Baseline and the Risk-Based End States is the point of compliance for ground water, both End States are represented on a single Conceptual Site Model.

End States

Three end state exposure scenarios are described and compared:

1. Current State – Conditions at Site 300 in 2003.
2. Current Cleanup Baseline End State – The end state the site will be in after implementing the existing cleanup strategy. This is based on the current and anticipated requirements of the baseline work plan documents, compliance agreements and Records of Decision, and environmental regulations. The point of compliance is the impacted ground water body, both onsite and offsite.
3. Risk-Based End State – The end state the site would be in based on planned future site use that is protective of human health and the environment for that site use. The point of compliance would be the site boundary.

The only significant strategic difference between the Current Cleanup Baseline End State and the Risk-Based End State is the point of compliance for contaminated ground water. The two end states are identical in terms of exposure of offsite receptors to contaminants from Site 300, and address risk to these receptors equivalently. However, onsite cleanup of ground water under the Current Cleanup Baseline End State is intended to restore and protect ground water as a potential future resource, rather than to specifically mitigate risk. The Risk-Based End State presents a scenario based only on risk, but does not remediate onsite ground water to levels protective of ground water as a potential future resource.

Hazard Area Description

Hazard Area 1 is defined as soil and/or ground water contamination resulting from high-explosive rinsewater lagoons and firing tables, test facilities, and machine shops in ten areas at Site 300. Contaminants include VOCs, high-explosive compounds, metals, tritium, depleted uranium, perchlorate, PCBs, and nitrate. Primary sources include discharges of contaminants to dry wells (sumps), surface spills at facilities, piping leaks, infiltration from unlined high-explosive rinse water lagoons, and high-explosive test detonations. Secondary sources include surface soil, vadose zone soil and bedrock, ground water, surface water, and ambient indoor and outdoor air. Maximum concentrations of contaminants are presented in Table 1.

Release Mechanisms

The only release mechanism is leakage or discharge of contaminants to surface soil or the vadose zone. Volatilization of contaminants directly from the released contaminant is not applicable because contaminants have already migrated into environmental media or been excavated. No active primary sources remain. It is assumed that the release mechanisms under the Current Cleanup Baseline End State and Risk-Based End State exposure scenarios are equivalent.

Transport Mechanisms

Potential transport mechanisms include volatilization of contaminants from surface soil or the vadose zone to ambient indoor and outdoor air, resuspension of contaminated soil particles to outdoor ambient air, infiltration of contaminants from the vadose zone to ground water, and outflow from ground water to surface water. It is assumed that the transport mechanisms under the Current Cleanup Baseline End State and Risk-Based End State exposure scenarios are equivalent.

Exposure Mechanisms and Receptors

In the baseline risk assessment, all potential exposure mechanisms and receptors were considered. Exposure mechanisms and receptors for which no unacceptable risk or hazard was identified in the baseline risk assessment are not discussed further. The risks and hazards to human and receptors are summarized in Table 2. Hazards to ecological receptors are summarized in Table 3. In Hazard Area 1, unacceptable risk or hazard was identified for the following exposure mechanisms and receptors.

Inhalation of volatile contaminants in indoor ambient air by onsite industrial workers

Risk and hazard were calculated for volatile contaminants in subsurface soil migrating upward through the floors of buildings into indoor ambient air and being inhaled by workers within the building. This assessment assumed that an onsite worker would spend 8 hours a day, 5 days a week, for 30 years within the buildings. An unacceptable risk or hazard was identified at:

- Building 834D - Cumulative risk 1×10^{-3}, hazard index 35.7, due to TCE and PCE.

Figure 4.1a2,b2. Hazard Area 1: Facility Contaminant Releases CSM – Current State and RBES (page 2 of 6).

- Building 854A - Cumulative risk 1×10^{-6}, due to six VOCs.
- Building 854F - Cumulative risk 9×10^{-6}, due to TCE, chloroform, and other VOCs.
- Building 830 - Cumulative risk 2×10^{-6}, due to TCE and vinyl chloride.
- Building 832F - Cumulative risk 3×10^{-6}, due to dichloropropane.
- Building 833 - Cumulative risk 1×10^{-6}, due to TCE and chloroform.
- Building 875 – Cumulative risk of 1×10^{-5}, due to TCE, PCE, 1,1-dichloroethylene, benzene, chloroform, and methylene chloride.

Under both the Current Cleanup Baseline End State and the Risk-Based End State, these risks will be mitigated through active remediation (soil vapor extraction) and managed using institutional controls.

Inhalation of volatile contaminants in outdoor ambient air by onsite industrial workers

Risk and hazard were calculated for volatile contaminants in subsurface soil migrating upward into outdoor ambient air and being inhaled by onsite workers. This assessment assumed a worker would spend 8 hours a day, 5 days a week, for 30 years working in these areas. An unacceptable risk or hazard was identified at:

- Building 834D - Cumulative risk 7×10^{-4}, hazard index 21.4, due to TCE and PCE.
- Building 815 - Cumulative risk 5×10^{-6}, due to TCE and PCE.
- Building 854F - Cumulative risk 1×10^{-5}, due to chloroform and 1,2-DCA.
- Building 830 - Cumulative risk 1×10^{-5}, due to chloroform, 1,2-DCA, and vinyl chloride.

Under both the Current Cleanup Baseline End State and the Risk-Based End State, these risks will be mitigated through active remediation (soil vapor extraction) and managed using institutional controls.

Inhalation, ingestion, and dermal contact with contaminants in surface soil by onsite industrial workers

Risk and hazard were calculated for inhalation of resuspended particulates, incidental ingestion of surface soil, and direct dermal contact with contaminated surface soil. These estimates assumed an onsite worker would spend 8 hours a day, 5 days a week, for 30 years working near the contamination. An unacceptable risk was identified at:

- Building 850 - Cumulative risk 5×10^{-3}, due to PCBs, dioxins, and furans.
- Building 855 - Cumulative risk 3×10^{-3}, due to PCBs, dioxins, and furans.

Under both the Current Cleanup Baseline End State and the Risk-Based End State, these risks will be mitigated through active remediation (excavation) and managed using institutional controls.

Ingestion of contaminated ground water by offsite residential receptors

Unacceptable future risks were identified at several existing offsite wells and hypothetical (i.e., not currently existing or planned) water-supply wells that could be installed at the Site 300 boundary. Unacceptable risks up to 7×10^{-2} were associated with the potential ingestion of ground water over a 30-year period from a hypothetical offsite wells. Under both the Current Cleanup Baseline End State and the Risk-Based End State, these risks will be mitigated through active remediation (ground water extraction).

Ingestion of contaminated ground water by onsite industrial receptors

Onsite water-supply well 20 is currently used to supply water to workers at Site 300 and is monitored regularly. VOCs have been sporadically detected in samples from this well at concentrations below the drinking water standard. LLNL plans to connect to the Hetch-Hetchy water-supply system in the near future and no additional water-supply wells are planned for Site 300. All other water-supply wells at Site 300 are used only as backup wells for fire suppression, or have been sealed and abandoned.

Under the Current Cleanup Baseline End State, onsite ground water contamination will be remediated through ground water extraction or monitored natural attenuation, with the point of compliance being the impacted ground water body. Under the Risk-Based End State, onsite ground water contamination would be remediated to the extent necessary to protect offsite receptors, with the point of compliance being the site boundary. Remaining onsite contamination would be managed using institutional controls.

Inhalation of VOCs volatilizing from surface water by onsite industrial receptors

Risk and hazard were calculated for contaminants in surface water volatilizing into the atmosphere and being inhaled by onsite workers. This assessment assumed an onsite worker would spend 8 hours a day, 5 days a week, for 30 years working near the contaminated surface water. An unacceptable risk or hazard was identified at:

- Spring 5 (High Explosives Process Area) - Cumulative risk 1×10^{-5}, due to 1,1-DCE and TCE.
- Spring 3 (Building 832 Canyon) - Cumulative risk 6×10^{-5}, hazard index 2.3, due to TCE and PCE.

Under the Risk-Based End State, onsite ground water contamination would be remediated to the extent necessary to protect offsite receptors, with the point of compliance being the site boundary. Remaining onsite contamination would be managed using institutional controls.

Figure 4.1a2,b2. Hazard Area 1: Facility Contaminant Releases CSM – Current State and RBES (page 3 of 6).

Inhalation of VOCs in Subsurface Burrow Air (Ecological)

Hazard (defined as a hazard index greater than 1) to species important at the individual level (referred to as "important" species), was identified for ground squirrel and kit fox associated with the inhalation of VOCs in burrow air in the Building 834 area. Risk management would continue under both the Current Cleanup Baseline End State and Risk-Based End State scenarios.

Ingestion and Inhalation of Cadmium, PCBs, Dioxins, and Furans in Surface Soil (Ecological)

Hazard was associated with the combined oral ingestion and inhalation of cadmium in the Building 834 area, and PCBs, dioxins, and furans in the Building 850 area. Hazard was identified for ground squirrel, deer, and kit fox. Risk management would continue under both the Current Cleanup Baseline End State and Risk-Based End State scenarios.

Remediation and Mitigation

Exposure Barrier 1 - Soil Vapor Extraction

Soil vapor extraction has been implemented at four contaminant release sites in Hazard Area□ to: (1) mitigate risk associated with inhalation of VOCs volatilizing from subsurface soil, and (2) protect ground water from potential or further degradation due to downward migration of contaminants from the vadose zone. Specifically, removing contaminants from the vadose zone by soil vapor extraction reduces risk due to:

- Inhalation of contaminated indoor and outdoor ambient air by onsite workers and special-status burrowing animals.
- Ingestion of onsite and offsite ground water. Protection of ground water leads to mitigation of risk to onsite and offsite receptors through a ground water exposure pathway.

Under the Current Cleanup Baseline End State scenario, onsite soil vapor extraction would be continued until: (1) the cancer risk associated with the inhalation of VOCs volatilizing from subsurface soil by onsite workers is reduced to less than 10^{-6} and a noncarcinogenic hazard index of 1, and (2) vadose zone concentrations protective of onsite and offsite ground water are achieved. There is no offsite vadose zone contamination that presents an unacceptable risk to offsite receptors. The time or cost remaining to achieve this objective has not been determined.

Under the Risk-Based End State scenario, onsite soil vapor extraction would be continued until the inhalation risk to onsite workers is mitigated and concentrations protective of offsite ground water are achieved. The time or cost remaining to achieve this objective has not been determined.

The residual risk under both End States will be below 10^{-6}, achieved either by active remediation or institutional controls.

Uncertainties or failure modes for this exposure barrier include:

- Changing subsurface conditions (e.g., unanticipated influx of moisture to the subsurface) could reduce the efficiency of soil vapor extraction or mobilize contaminants.
- Soil vapor extraction may not adequately remove contaminants from the vadose zone to the extent necessary to protect ground water from further degradation in a reasonable timeframe.

These uncertainties/failure modes apply to both the Current Cleanup Baseline and Risk-Based End States.

Exposure Barrier 2 - Ground Water Extraction

Ground water extraction has been implemented in 13 areas in Hazard Area□. Specifically, removing contaminants from ground water by extraction reduces risk due to:

- Ingestion of ground water by onsite and offsite human receptors.
- Inhalation of VOCs by onsite human (industrial) receptors where contaminated ground water discharges at springs.

Although cleanup standards for ground water have not been established for most contaminant release sites in Hazard Area□, the remedies were designed assuming that concentrations consistent with unrestricted land use must be achieved both onsite and offsite (at least as protective as MCLs).

Under the Current Baseline End State scenario, ground water extraction would be continued until concentrations consistent with unrestricted use are achieved both onsite and offsite. The point of compliance is the impacted ground water body. There will be no unacceptable residual risk to all identified receptors if land use remains as anticipated.

Under the Risk-Based End State scenario, ground water extraction would be limited to ensuring that MCLs (or lower) are achieved and maintained offsite. The point of compliance would be the site boundary. For ingestion of ground water, there would be no unacceptable residual risk to all identified receptors if land use remains as anticipated. A residual risk would remain for inhalation of VOCs by onsite workers at springs but has not been quantified.

Uncertainties or failure modes for this exposure barrier include:

- Changing subsurface conditions (e.g., unanticipated recharge) affect the effectiveness of ground water extraction.
- Ground water extraction may not adequately remove contaminants to the extent required to achieve cleanup standards, or protect offsite receptors, in a reasonable timeframe.
- Changes in ground water use, including installation of water-supply wells adjacent to Site 300. In addition to being receptor points for human consumption of ground water, offsite wells could alter ground water flow patterns and result in unanticipated contaminant migration toward the wells.

These uncertainties/failure modes apply to both the Current Cleanup Baseline and Risk-Based End States.

Exposure Barrier 3 - Monitored Natural Attenuation

Monitored natural attenuation has been implemented at one contaminant release site in Hazard Area 1 (tritium at Building 850). The risk reduction achieved through monitored natural attenuation is equivalent to that previously described for ground water extraction.

Under both the Current Cleanup Baseline End State and Risk-Based End State scenarios, monitored natural attenuation may be implemented at additional areas in a manner consistent with existing regulations and guidelines. However, the point of compliance for the Current Cleanup Baseline End State is the impacted ground water body. Under the Risk-Based End State the point of compliance would be the site boundary. There would be no unacceptable residual risk to all identified receptors if land use remains as anticipated.

Uncertainties or failure modes for this exposure barrier include:

- Changing subsurface conditions (e.g., unanticipated recharge) affect the effectiveness of monitored natural attenuation.
- Natural attenuation may not adequately degrade contaminants to the extent required to achieve cleanup standards, or protect offsite receptors, in a reasonable timeframe.
- Degradation could result in the formation of daughter products more toxic, persistent, or mobile than the original contaminant.
- Changes in ground water use, including installation of water-supply wells adjacent to Site 300. In addition to being receptor points for human consumption of ground water, offsite wells could alter ground water flow patterns and result in unanticipated contaminant migration toward the wells.

These uncertainties/failure modes apply to both the Current Cleanup Baseline and Risk-Based End States.

Exposure Barrier 4 - Soil Excavation

Soil excavation has been completed at several of the release sites in Hazard Area 1. Soil excavation reduces the potential and/or magnitude of risks resulting from exposure to primary source contamination and from leaching into the underlying vadose zone.

Under the Current Cleanup Baseline End State and Risk-Based End State scenarios, the excavation currently planned to mitigate risk from PCBs, dioxins, and furans in soil at Buildings 850 and 855 would be completed, but no additional excavation is anticipated. There would be no unacceptable residual risk to all identified receptors if land use remains as anticipated.

There are no identified uncertainties or failure modes associated with this exposure barrier.

Exposure Barrier 5 - Institutional Controls

Institutional controls protect human health by restricting access to or activities in areas of elevated risk or hazard (institutional controls), thereby preventing unacceptable exposure to contaminants during the remediation process. Engineering controls are implemented to mitigate exposure when institutional controls are not sufficient to manage exposure. The primary mechanism to implement many institutional controls at Site 300 is the Risk and Hazard Management Plan, contained within the Compliance Monitoring Plan/Contingency Plan for Interim Remedies at Site 300.

Institutional controls, such as onsite building access and local site use restrictions, are currently a component of many of the risk management actions at Site 300. Current building occupancy and site use restrictions will be maintained in areas identified to have an unacceptable risk or hazard until revised risk assessments show that the risk or hazard has been reduced to acceptable levels. Fencing and a full-time security force prevent access to Site 300 by unauthorized members of the public. Site 300 building occupancy and site use restrictions are necessary only to prevent exposure of onsite workers. These restrictions are implemented and maintained by Site 300 management. Currently, no Site 300 staff work full-time in any area or building where an unacceptable risk or hazard has been identified. Warning signs are posted in all areas and buildings where an unacceptable risk or hazard has been identified, stating that permanent occupancy of the facility (or area) on a full-time basis must be approved by the LLNL Hazards Control Department.

Figure 4.1a2,b2. Hazard Area 1: Facility Contaminant Releases CSM – Current State and RBES (page 5 of 6).

Under some circumstances, full-time building occupancy or local site use may be required in areas where and unacceptable risk or hazard has been identified. In these cases, engineering controls will be implemented to prevent unacceptable worker exposure to contaminants. Engineering controls may include installing a building ventilation system, paving an area to minimize volatilization of contaminants into the atmosphere, or requiring personal protective equipment while in the area. If construction or other temporary ground-disturbing activities become necessary in areas of soil contamination, controls such as wetting the soil to prevent resuspension of soil particles or the use of personal protective equipment will be implemented.

Other institutional controls include:

- Controlling water use from onsite water-supply wells to prevent human ingestion of potential contaminants.
- Monitoring for special-status burrowing species is performed where the hazard index exceeds 1.

It is assumed that these controls would be maintained under both the Current Cleanup Baseline End State and Risk-Based End State scenarios. There will be no unacceptable residual risk to all identified receptors if land use remains as anticipated.

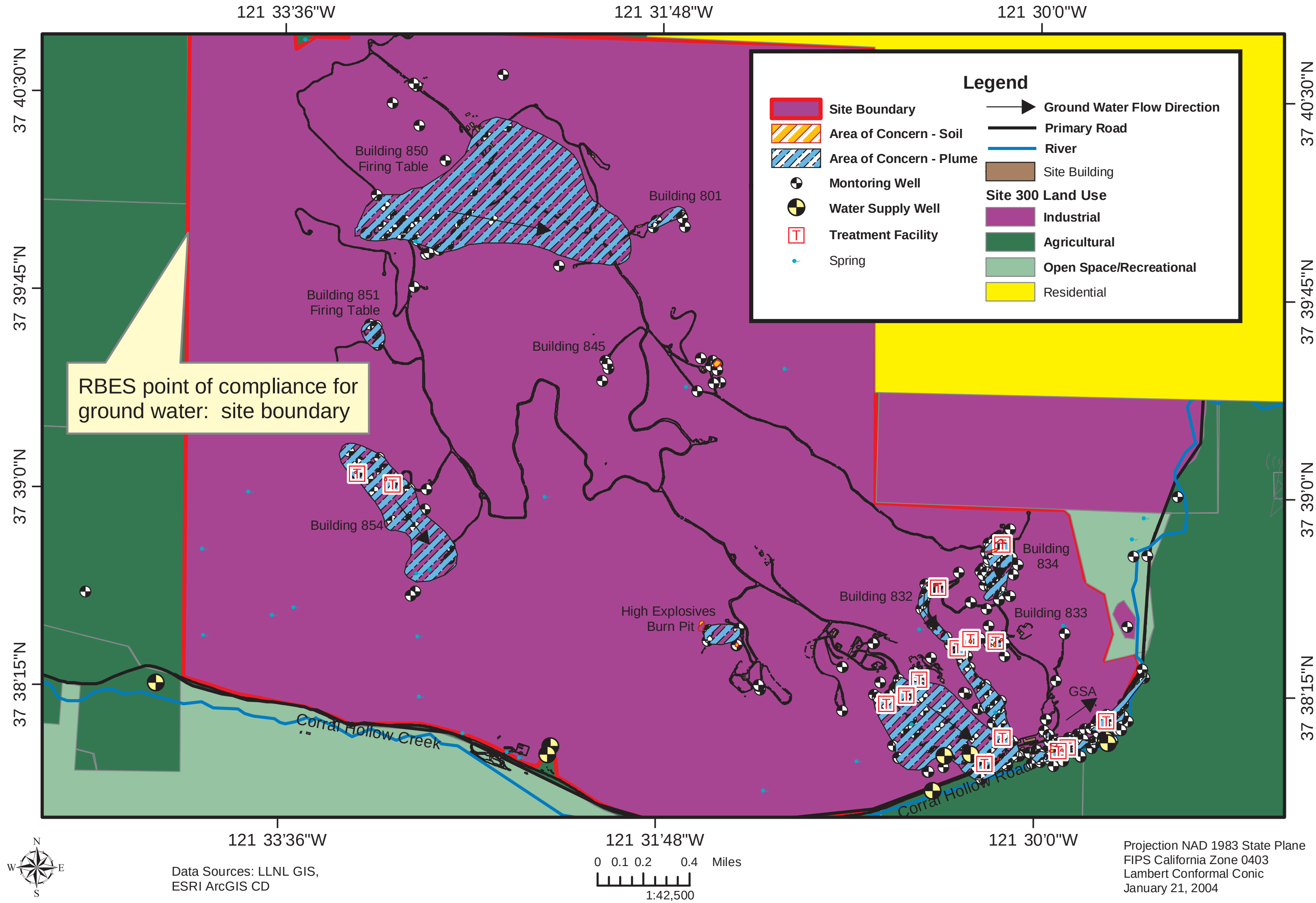
Uncertainties or failure modes for this exposure barrier include:

- In the event of a transfer of ownership of the Site 300 to another entity, DOE would have to ensure that it met its responsibilities under Section 120 of CERCLA, which obligates DOE to clean up contamination resulting from DOE activities, or any future contamination resulting from DOE activities at the Site 300. In addition, no change of ownership of the site or any portion thereof could be performed by DOE without provision for continued maintenance of any containment system, treatment system, monitoring system, or other response action(s) installed or implemented.

This uncertainty/failure mode applies to both the Current Cleanup Baseline and Risk-Based End States.

Figure 4.1a2,b2. Hazard Area 1: Facility Contaminant Releases CSM – Current State and RBES (page 6 of 6).

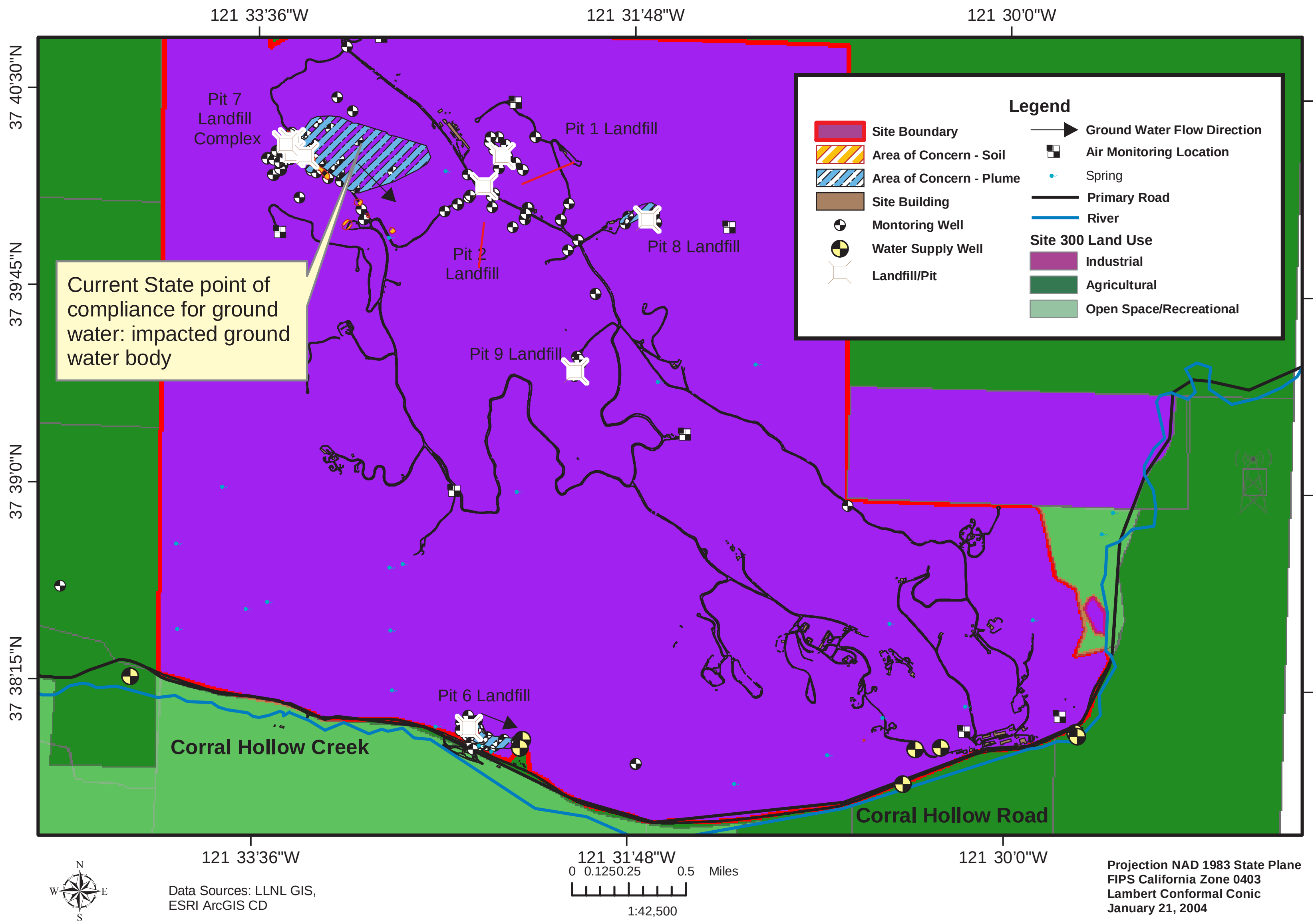
Figure 4.1b1. Hazard Area 1: Facility Contaminant Releases Map - RBES.



Data Sources: LLNL GIS,
ESRI ArcGIS CD

Projection NAD 1983 State Plane
FIPS California Zone 0403
Lambert Conformal Conic
January 21, 2004

Figure 4.2a1. Hazard Area 2: Landfills Map - Current State.



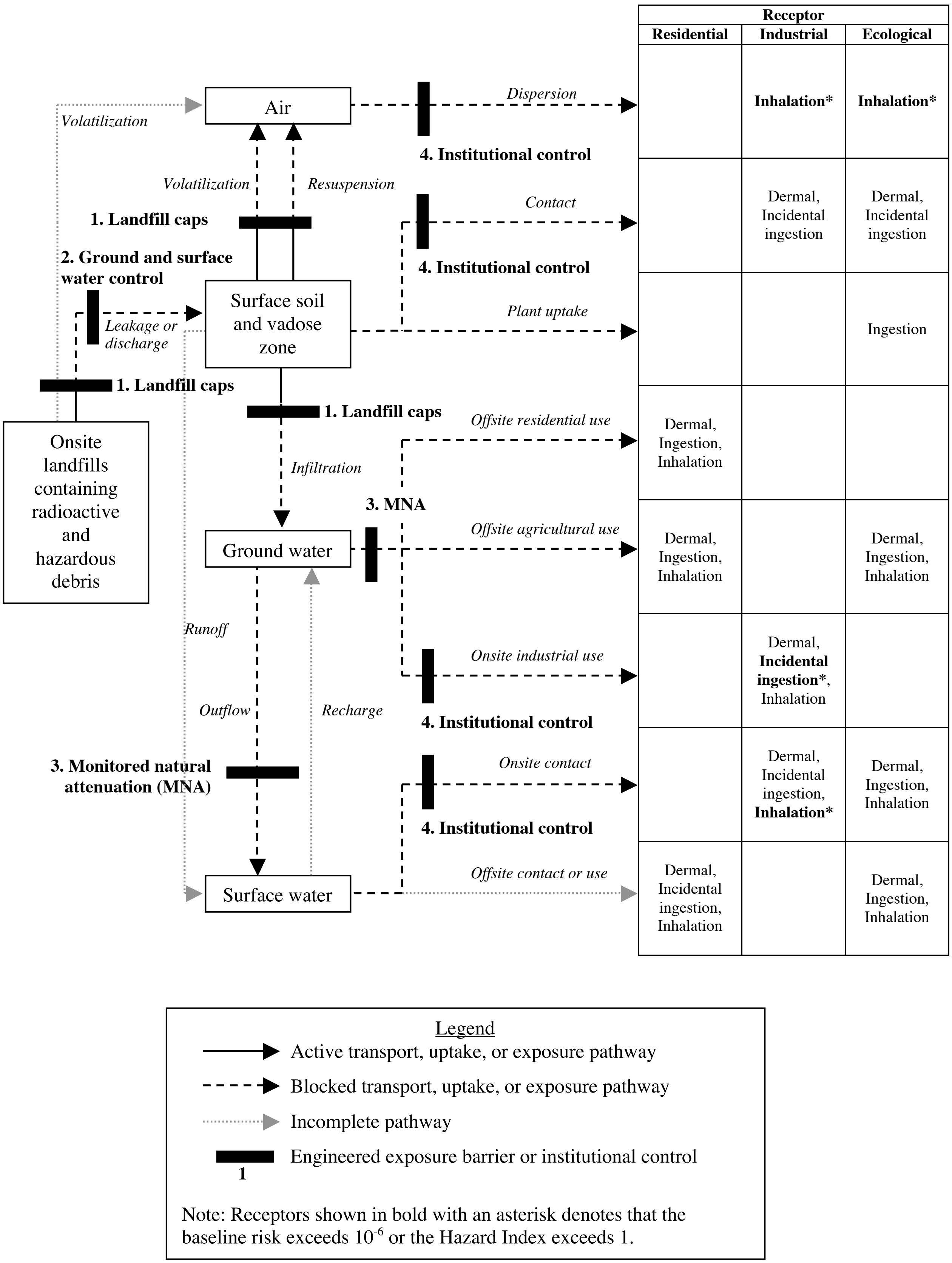


Figure 4.2a2,b2. Hazard Area 2: Onsite Landfills CSM – Current State and RBES (page 1 of 4).

Narrative for Hazard Area 2 Current State and RBES Exposure Scenarios CSM (Figure 4.2a2,b2)

This narrative provides a summary of information presented in Section 4 of this Risk-Based End State Vision document. Because the only difference between the Current Cleanup Baseline and the Risk-Based End States is the point of compliance for ground water, both End States are represented on a single Conceptual Site Model.

End States

Three end state exposure scenarios are described and compared:

1. Current State – Conditions at Site 300 in 2003.
2. Current Cleanup Baseline End State – The end state the site will be in after implementing the existing cleanup strategy. This is based on the current and anticipated requirements of the baseline work plan documents, compliance agreements and Records of Decision, and environmental regulations. The point of compliance is the impacted ground water body, both onsite and offsite.
3. Risk-Based End State – The end state the site would be in based on planned future site use that is protective of human health and the environment for that site use. The point of compliance would be the site boundary.

The only significant strategic difference between the Current Cleanup Baseline End State and the Risk-Based End State is the point of compliance for contaminated ground water. The two end states are identical in terms of exposure of offsite receptors to contaminants from Site 300, and address risk to these receptors equivalently. However, onsite cleanup of ground water under the Current Cleanup Baseline End State is intended to restore and protect ground water as a potential future resource, rather than to specifically mitigate risk. The Risk-Based End State presents a scenario based only on risk, but does not remediate onsite ground water to levels protective of ground water as a potential future resource.

Hazard Area Description

Hazard Area 2 is defined as the nine landfills located within the Site 300 boundary. Radioactive and hazardous waste from site operations was placed in these unlined landfills from the 1950s through the 1980s. Engineered caps have been placed on several of the landfills. Releases from some of the landfills have resulted in soil and ground water contamination, primarily by VOCs, depleted uranium, and tritium.

The primary sources in Hazard Area 2 are the landfill debris. Secondary sources include vadose zone soil/bedrock and ground water. Maximum concentrations of contaminants are presented in Table 1.

Release Mechanisms

The only release mechanism for the landfills is leaching of contaminants in the landfill contents to the vadose zone. The primary transport mechanism at the landfills is infiltration of contaminants from the vadose zone to ground water. Receptors include onsite workers and onsite ecological species. It is assumed that the release mechanisms under the Current Cleanup Baseline End State and Risk-Based End State exposure scenarios are equivalent.

Transport Mechanisms

The primary transport mechanism at the landfills is infiltration of contaminants from the vadose zone to ground water. It is assumed that the release transport under the Current Cleanup Baseline End State and Risk-Based End State exposure scenarios are equivalent.

Exposure Mechanisms and Receptors

In the baseline risk assessment, all potential exposure mechanisms and receptors were considered. Exposure mechanisms and receptors for which no unacceptable risk or hazard was identified in the baseline risk assessment are not discussed further. The risks and hazards to human and receptors are summarized in Table 2. Hazards to ecological receptors are summarized in Table 3. In Hazard Area 2, unacceptable risk or hazard was identified for the following exposure mechanisms and receptors.

Inhalation of VOCs volatilizing from subsurface soil to outdoor ambient air

Risk and hazard were calculated for volatile contaminants in subsurface soil migrating upward into outdoor ambient air and being inhaled by onsite workers. This assessment assumed a worker would spend 8 hours a day, 5 days a week, for 30 years working in these areas. An unacceptable inhalation risk of 5×10^{-6} was identified for onsite industrial receptors at the Pit 6 Landfill due to multiple VOCs. Although an unacceptable risk was identified in the baseline risk assessment, an engineered cap was later placed over the Pit 6 Landfill that includes an impermeable geomembrane layer covering the entire landfill area that prevents VOC vapors from reaching

Figure 4.2a2,b2. Hazard Area 2: Onsite Landfills CSM – Current State and RBES (page 2 of 4).

outdoor ambient air where workers could be exposed. No further risk management measures to prevent inhalation of VOCs are needed.

Inhalation of VOCs volatilizing from surface water to outdoor ambient air

Risk and hazard were calculated for contaminants in surface water volatilizing into the atmosphere and being inhaled by onsite workers. This assessment assumed an onsite worker would spend 8 hours a day, 5 days a week, for 30 years working near the contaminated surface water. An unacceptable risk or hazard was identified at:

- Spring 7 (southeast of the Pit 6 Landfill) - Cumulative risk 4×10^{-5}, hazard index 1.1, due to TCE, PCE 1,2-DCA, and chloroform.
- The Carnegie State Vehicular Recreation Area pond (east of the Pit 6 Landfill): Cumulative risk 2×10^{-6}, due to TCE.

Under both the Current Cleanup Baseline End State and the Risk-Based End State, this risk would be remediated using monitored natural attenuation and managed using institutional controls.

Inhalation of VOCs in Subsurface Burrow Air (Ecological)

Hazard (defined as a hazard index greater than 1) to species important at the individual level (referred to as "important" species), was identified for ground squirrel and kit fox associated with the inhalation of VOCs in burrow air in the Pit 6 Landfill area. Risk management would continue under both the Current Cleanup Baseline End State and Risk-Based End State scenarios.

Remediation and Mitigation

Exposure Barrier 1 - Landfill Caps and Covers

An engineered cap was placed over the Pit 6 Landfill that includes an impermeable geomembrane layer covering the entire landfill area that prevents: (1) VOC vapors from reaching outdoor ambient air where workers could be exposed, (2) infiltration of precipitation and resultant mobilization/leaching of contaminants in the landfill debris, and (3) direct contact with the landfill contents. Although no inhalation risk has been identified at the Pits 1, 4 and 7 landfills, engineered caps prevent infiltration of precipitation and resultant mobilization/leaching of contaminants in the landfill debris and direct contact with the landfill contents. Additional controls to prevent impacts to ground water are being evaluated in the Remedial Investigation/Feasibility Study for the Pit 7 Complex.

Under both the Current Cleanup Baseline End State and Risk-Based End State scenarios, these caps would be monitored and maintained for as long as the waste remains a potential threat to receptors or to ground water quality. There would be no unacceptable residual risk to all identified receptors if land use remains as anticipated.

Uncertainties or failure modes for this exposure barrier include:

- Unidentified breaching or damage to the landfill surface could result in exposure to the landfill contents or allow precipitation or surface water to enter the landfill, mobilizing contaminants from the landfill debris.
- Ensuring the performance of long-term monitoring and maintenance.

These uncertainties/failure modes apply to both the Current Cleanup Baseline and Risk-Based End States.

Exposure Barrier 2 - Ground and Surface Water Control

Ground and surface water controls have been implemented or planned for several landfills. These controls are designed to prevent water from infiltrating through the landfill caps/covers and to prevent ground water from rising into the landfills and subsequent mobilization of contaminants.

Under both the Current Cleanup Baseline End State and Risk-Based End State scenarios, these systems would be monitored and maintained for as long as the waste remains a potential threat to receptors or to ground water quality. There would be no unacceptable residual risk to all identified receptors if land use remains as anticipated.

Uncertainties or failure modes for this exposure barrier include:

- The ability of the ground and surface water control systems to adequately prevent mobilization of contaminants from the landfill contents.
- Ensuring long-term maintenance of the systems.

These uncertainties/failure modes apply to both the Current Cleanup Baseline and Risk-Based End States.

Exposure Barrier 3 - Monitored Natural Attenuation

A monitored natural attenuation remedy has been implemented for TCE at the Pit 6 Landfill under the Current State exposure scenario.

Figure 4.2a2,b2. Hazard Area 2: Onsite Landfills CSM – Current State and RBES (page 3 of 4).

Under both the Current Cleanup Baseline End State and Risk-Based End State scenarios, monitored natural attenuation may be implemented at additional areas in a manner consistent with existing regulations and guidelines. However, the point of compliance for the Current Cleanup Baseline End State is the impacted ground water body. Under the Risk-Based End State the point of compliance would be the site boundary. There would be no unacceptable residual risk to all identified receptors if land use remains as anticipated.

Uncertainties or failure modes for this exposure barrier include:

- Changing subsurface conditions (e.g., unanticipated recharge) affect the effectiveness of monitored natural attenuation.
- Natural attenuation may not adequately degrade contaminants to the extent required to achieve cleanup standards, or protect offsite receptors, in a reasonable timeframe.
- Degradation could result in the formation of daughter products more toxic, persistent, or mobile than the original contaminant.
- Changes in ground water use, including installation of water-supply wells adjacent to Site 300. In addition to being receptor points for human consumption of ground water, offsite wells could alter ground water flow patterns and result in unanticipated contaminant migration toward the wells.

These uncertainties/failure modes apply to both the Current Cleanup Baseline and Risk-Based End States.

Exposure Barrier 4 - Institutional Controls

In addition to the institutional controls described for Hazard Area 1 (Section 4.1.5.5) the following controls are applicable to the landfills at Site 300:

- The LLNL Environmental Restoration Division coordinates with Site 300 management to ensure that no excavation occurs in areas of contamination or at landfills except for approved remedial actions or under the supervision of the LLNL Hazards Control Department. Activities in landfill areas are restricted to those that will not expose landfill material or compromise the integrity of the landfill surfaces.
- Monitoring for special-status burrowing species is performed where the hazard index exceeds 1.

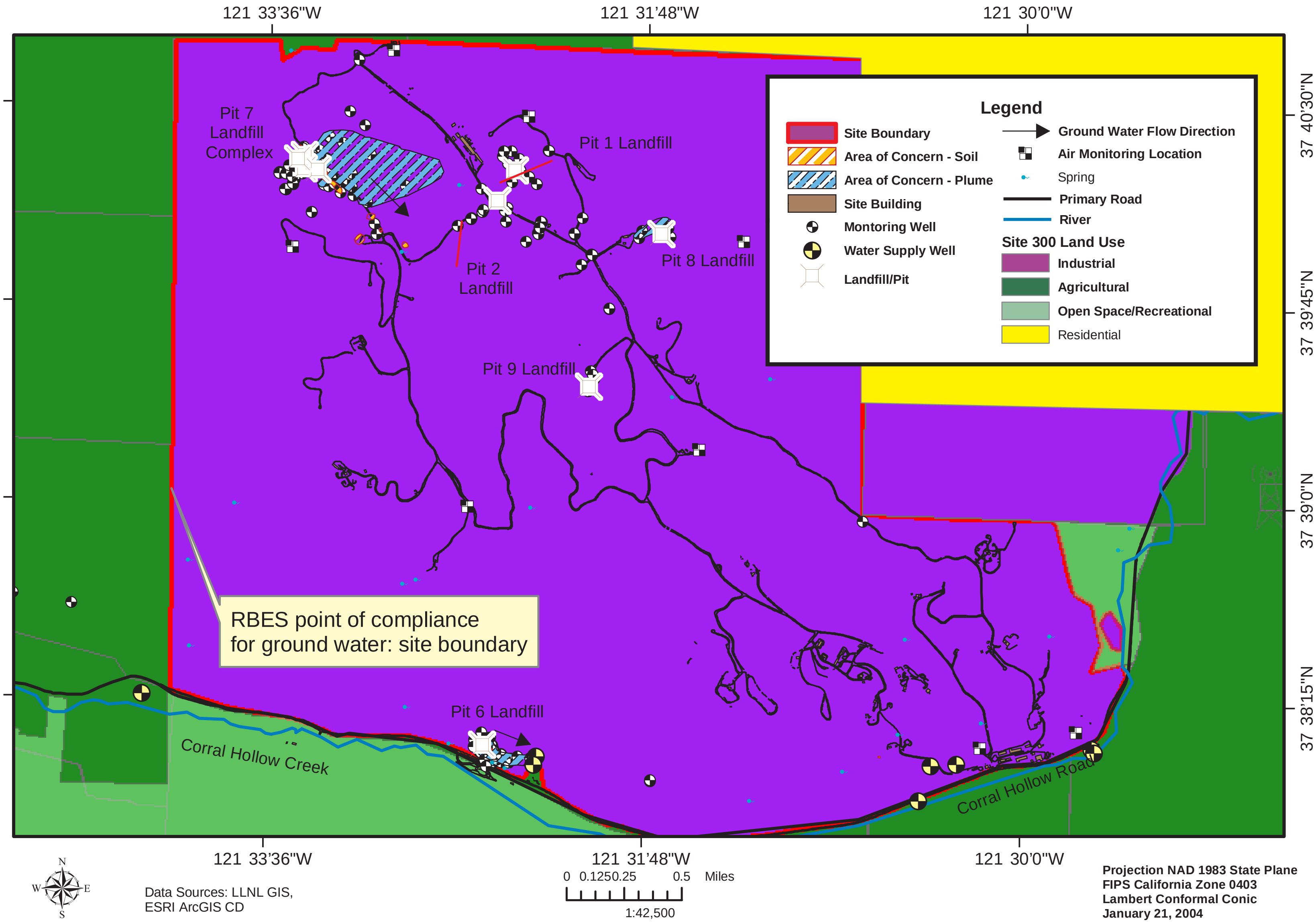
It is assumed that these controls would be maintained under both the Current Cleanup Baseline End State and Risk-Based End State scenarios. There will be no unacceptable residual risk to all identified receptors if land use remains as anticipated.

Uncertainties or failure modes for this exposure barrier include:

- In the event of a transfer of ownership of the Site 300 to another entity, DOE would have to ensure that it met its responsibilities under Section 120 of CERCLA, which obligates DOE to clean up contamination resulting from DOE activities, or any future contamination resulting from DOE activities at Site 300. In addition, no change of ownership of the site or any portion thereof could be performed by DOE without provision for continued maintenance of any containment system, treatment system, monitoring system, or other response action(s) installed or implemented.

Figure 4.2a2,b2. Hazard Area 2: Onsite Landfills CSM – Current State and RBES (page 4 of 4).

Figure 4.2b1. Hazard Area 2: Landfills Map - RBES.



Tables

Table 1. Current maximum concentrations of selected COCs in ground water at LLNL Site 300.

Area	TCE (µg/L)	RDX (µg/L)	Nitrate (as NO_3) (mg/L)	Perchlorate (µg/L)	Tritium (pCi/L)	Uranium (pCi/L)
Regulatory Standard	*5 (MCL)*	*0.6 (EPA Region IX PRG)*	*45 (MCL)*	*4 (CA Action Level)*	*20,000 (MCL)*	*20 (MCL)*
General Services Area	**710**	**–**	**–**	**–**	**–**	**–**
Building 834	**201,000**	**–**	**110**	**–**	**–**	**–**
Pit 6 Landfill	**5.3**	**–**	**160**	**12**	**1,850**	**–**
HE Process Area	**130**	**100**	**150**	**17**	**–**	**–**
Building 850	**–**	**–**	**140**	–	**81,400**	**17.1 (U238)**
Pit 7 Complex	**2.8**	**–**	**363**	**19**	**469,000**	**122.9 (U238)**
Building 854	**210**	**–**	**57**	**27**	**–**	**–**
Building 832 Canyon	**13,000**	**–**	**190**	**13**	**–**	**–**
Building 801	**1.4**	**–**	**39**	**5**	**–**	**–**
Building 833	**<0.5**	**–**	**–**	**–**	**–**	**–**
Building 845	**–**	**–**	**–**	**–**	**–**	**–**
Building 851	**–**	**–**	**–**	**–**	**270**	**0.102 (U238)**

Notes:

COC = Contaminant of concern.

MCL = Maximum Contaminant Level.

PRG = Preliminary Remediation Goal.

RDX = Research Department Explosive.

U238 = Uranium-238 (depleted uranium).

– = Not a COC.

Table 2. Summary of human health risks and hazards identified in the Site 300 baseline risk assessment.

Area	Exposure media: pathway	Contaminant	Baseline risk	Baseline hazard quotient	Comments
Building 834	Volatilization from subsurface soil: Inhalation inside Building 834D	TCE	9×10^{-4}	35	Building used only for storage.
		PCE	1×10^{-4}	0.7	
	Cumulative risk, hazard index:		*1×10^{-3}*	*35.7*	
Building 834	Volatilization from subsurface soil: Inhalation outside Building 834D	TCE	6×10^{-4}	21	No full-time use.
		PCE	8×10^{-5}	0.4	
	Cumulative risk, hazard index:		*7×10^{-4}*	*21.4*	
General Services Area (Central)	Volatilization from subsurface soil: Inhalation inside Building 875	TCE	7×10^{-6}	<1	
		PCE	4×10^{-6}	<1	
		1,1-DCE	2×10^{-7}	<1	
		Benzene	1×10^{-7}	NA	
		Methylene chloride	4×10^{-9}	<1	
		Chloroform	3×10^{-7}	<1	
	Cumulative risk, hazard index:		*1×10^{-5}*	<1	Risk recalculated in 2000 to be less than 10^{-6}
General Services Area (Eastern)	Ingestion of ground water from hypothetical water-supply well at site boundary near the debris burial trenches	TCE	2×10^{-5}	<1	Modeling based on pre-1993 concentrations for VOCs, all currently below baseline.
		PCE	4×10^{-6}	<1	
		1,1-DCE	2×10^{-5}	<1	
		Bromodichloromethane	4×10^{-7}	<1	
		Chloroform	1×10^{-5}	<1	
	Cumulative risk, hazard index:		*5×10^{-5}*	<1	
General Services Area (Central)	Ingestion of ground water from hypothetical water-supply well at site boundary near the Building 875 dry wells	TCE	2×10^{-2}	456	Modeling based on pre-1993 concentrations for VOCs, all currently below baseline.
		PCE	2×10^{-2}	85.1	
		1,1-DCE	4×10^{-2}	9.5	
		cis-1,2-DCE	NA	7.5	
		Benzene	2×10^{-4}	NA	
	Cumulative risk, hazard index:		*7×10^{-2}*	*560*	

Table 2. Summary of human health risks and hazards identified in the Site 300 baseline risk assessment. (Cont. page 2 of 5)

Area	Exposure media and pathway	Contaminant	Baseline risk	Baseline hazard quotient	Comments
General Services Area	**Ingestion of ground water from water-supply well CDF-1**	**TCE**	**5×10^{-6}**	**<1**	**Modeling based on pre-1993 concentrations for VOCs, all currently below baseline.**
		PCE	**2×10^{-6}**	**<1**	
		1,1-DCE	**6×10^{-6}**	**<1**	
		Benzene	**2×10^{-8}**	**NA**	
		Bromodichlo romethane	**4×10^{-8}**	**<1**	
		Chloroform	**1×10^{-6}**	**<1**	
		Cumulative risk, hazard index:	***1×10^{-5}***	**<1**	
General Services Area	**Ingestion of ground water from water-supply well SR-1**	**TCE**	**5×10^{-6}**	**<1**	**Modeling based on pre-1993 concentrations for VOCs, all currently below baseline.**
		PCE	**3×10^{-6}**	**<1**	
		1,1-DCE	**9×10^{-6}**	**<1**	
		Benzene	**3×10^{-8}**	**NA**	
		Bromodichlo romethane	**5×10^{-8}**	**<1**	
		Chloroform	**2×10^{-6}**	**<1**	
		Cumulative risk, hazard index:	***2×10^{-5}***	**<1**	
Pit 6 Landfill	**Volatilization from subsurface soil: Inhalation at landfill**	**VOCs**	**5×10^{-6}**	**<1**	**Landfill capped in 1998.**
		Cumulative risk, hazard index:	***5×10^{-6}***	***<1***	
Pit 6 Landfill	**Volatilization from surface water: Inhalation at Spring 7**	**TCE**	**3×10^{-5}**	**1.1**	**Current concentrations below baseline.**
		PCE	**1×10^{-6}**	**<1**	**One detection in last 10 years.**
		1,2-DCA	**3×10^{-6}**	**NC**	**Not detected for over 10 years. No hazard PRG available.**
		Chloroform	**3×10^{-6}**	**<1**	**Not detected for over 10 years.**
		Cumulative risk, hazard index:	***4×10^{-5}***	***1.1***	
Pit 6 Landfill	**Volatilization from surface water: Inhalation at SVRA pond**	**TCE**	**2×10^{-6}**	**<1**	**Not detected in SVRA pond.**
		Cumulative risk, hazard index:	***2×10^{-6}***	***<1***	

Table 2. Summary of human health risks and hazards identified in the Site 300 baseline risk assessment. (Cont. page 3 of 5)

Area	Exposure media and pathway	Contaminant	Baseline risk	Baseline hazard quotient	Comments
HE Process Area	**Volatilization from subsurface soil: Inhalation outside Building 815**	**TCE**	**4×10^{-6}**	**<1**	
		PCE	**1×10^{-6}**	**<1**	
		Cumulative risk, hazard index:	***5×10^{-6}***	***<1***	
HE Process Area	**Volatilization from surface water: Inhalation at Spring 5**	**1,1-DCE**	**8×10^{-6}**	**<1**	**Spring 5 represented by well W-817-03A. Not detected since 1987.**
		TCE	**5×10^{-6}**	**<1**	**Current concentration below baseline.**
		Cumulative risk, hazard index:	***1×10^{-5}***	***<1***	
HE Process Area	**Ground water: Ingestion at hypothetical well at site boundary**	**1,1-DCE**	**5×10^{-6}**	**<1**	**Modeling based on pre-1993 concentrations for VOCs, all currently below baseline.**
		TCE	**3×10^{-6}**	**<1**	
		RDX	**2×10^{-6}**	**<1**	
		Cumulative risk, hazard index:	***1×10^{-5}***	***<1***	
Building 850	**Surface soil: Inhalation, ingestion, and dermal contact in Building 850 area**	**PCBs**	**5×10^{-3}**	**NC**	**No hazard PRG available.**
		Dioxins and furans	**1×10^{-4}**	**NC**	**No hazard PRG available.**
		Cumulative risk, hazard index:	***5×10^{-3}***	***NC***	
Building 854	**Surface soil: Inhalation, ingestion, and dermal contact in Building 854 area**	**PCBs: Arochlor 1242, 1248**	**7×10^{-5}**	**NC**	**No hazard PRG available.**
		Cumulative risk, hazard index:	***7×10^{-5}***	***NC***	
Building 854	**Volatilization from subsurface soil: Inhalation inside Building 854F**	**Chloroform**	**5×10^{-6}**	**<1**	**Based on 1996 ambient air sample.**
		TCE	**3×10^{-7}**	**NC**	**Based on 1996 ambient air sample.**
		Other VOCs	**4×10^{-6}**	**<1**	**Not detected, risk calculated using detection limits.**
		Cumulative risk, hazard index:	***9×10^{-6}***	***<1***	
Building 854	**Volatilization from subsurface soil: Inhalation outside Building 854F**	**Chloroform**	**9×10^{-6}**	**<1**	**Based on 1996 ambient air sample.**
		1,2-DCA	**1×10^{-6}**	**<1**	**Not detected in soil.**
		Cumulative risk, hazard index:	***1×10^{-5}***	***<1***	

Table 2. Summary of human health risks and hazards identified in the Site 300 baseline risk assessment. (Cont. page 4 of 5)

Area	Exposure media and pathway	Contaminant	Baseline risk	Baseline hazard quotient	Comments
Building 854	**Volatilization from subsurface soil: Inhalation inside Building 854A**	**Six VOCs**	**1×10^{-6}**	**<1**	**Not detected, risk calculated using detection limits.**
		Cumulative risk, hazard index:	***1×10^{-6}***	***<1***	
Building 830	**Volatilization from subsurface soil: Inhalation inside Building 830**	**Vinyl chloride**	**2×10^{-6}**	**NC**	**Based on 1996 ambient air sample. Not detected in air flux measurements.**
		TCE	**3×10^{-7}**	**NC**	
		Cumulative risk, hazard index:	***2×10^{-6}***	***NC***	
Building 830	**Volatilization from subsurface soil: Inhalation outside Building 830**	**Chloroform**	**4×10^{-6}**	**NC**	**Based on 1996 ambient air samples.**
		1,2-DCA	**4×10^{-6}**	**NC**	**Not detected in vadose zone or in air flux measurements.**
		Vinyl chloride	**2×10^{-6}**	**NC**	**Not detected in vadose zone or in air flux measurements.**
		Cumulative risk, hazard index:	***1×10^{-5}***	***NC***	
Building 832	**Volatilization from subsurface soil: Inhalation inside Building 832F**	**Dichloro-propane**	**3×10^{-6}**	**NC**	**Based on 1996 ambient air samples. Not detected in air flux measurements.**
		Cumulative risk, hazard index:	***3×10^{-6}***	***NC***	
Building 832 Canyon	**Volatilization from surface water: Inhalation at Spring 3**	**TCE**	**6×10^{-5}**	**2.3**	**Current concentrations below baseline.**
		PCE	**5×10^{-6}**	**<1**	**Not detected in last 5 years.**
		Cumulative risk, hazard index:	***6×10^{-5}***	***2.3***	
Building 833	**Volatilization from subsurface soil: Inhalation inside Building 833**	**TCE**	**6×10^{-7}**	**<1**	
		Chloroform	**6×10^{-7}**	**<1**	
		Cumulative risk, hazard index:	***1×10^{-6}***	***<1***	

Notes appear on following page.

Table 2. Summary of human health risks and hazards identified in the Site 300 baseline risk assessment. (Cont. page 5 of 5)

Notes:

Only exposure pathways where the cumulative risk exceeded 10^{-6} or the hazard index exceeded 1 are shown. Data are from Webster-Scholten (1994).

DCA = Dichloroethane.
PCBs = Polychlorinated biphenyls.
PCE = Tetrachloroethylene.
PRG = U.S. EPA Preliminary Remediation Goal.
NA = Not available.
NC = Not calculated.
RDX = Research Department Explosive.
SVRA = Carnegie State Vehicular Recreation Area.
TCE = Trichloroethylene.
VOCs = Volatile organic compounds.

Table 3. Summary of hazards to ecological receptors identified in the Site 300 baseline risk assessment.

Area	Exposure pathway	Receptor	Contaminant	Baseline hazard quotient	Comments
Building 834	Inhalation	Individual ground squirrel (J&A)	TCE	>1	Surveys found no impact to the population.
	Inhalation	Individual kit fox (J&A)	TCE	>1	Surveys found no evidence of kit fox in area.
	Inhalation	Individual ground squirrel (J&A)	PCE	>1	Surveys found no impact to the population.
	Inhalation	Individual kit fox (J&A)	PCE	>1	Surveys found no evidence of kit fox in area.
	Oral ingestion	Individual adult ground squirrels	Cadmium	>1	Surveys found no impact to the population.
	Oral ingestion	Individual deer (J&A)	Cadmium	>1	Surveys found no impact to the population.
	Oral ingestion	Individual adult kit fox	Cadmium	>1	Surveys found no evidence of kit fox in area.
Pit 6 Landfill	Inhalation	Individual juvenile ground squirrel	TCE	>1	Surveys found no impact to the population.
	Inhalation	Individual kit fox (J&A)	TCE	>1	Surveys found no evidence of kit fox in area.
	Inhalation	Individual juvenile ground squirrel	PCE	>1	Surveys found no impact to the population.
	Inhalation	Individual juvenile kit fox	PCE	>1	Surveys found no evidence of kit fox in area.
	Inhalation	Individual adult ground squirrels	Total VOCs	>1	Surveys found no impact to the population.
	Inhalation	Individual adult kit fox	Total VOCs	>1	Surveys found no evidence of kit fox in area.
High Explosives Process Area	Oral and inhalation	Individual adult ground squirrels	Cadmium	>1	Surveys found no impact to the population.
	Oral and inhalation	Individual juvenile deer	Cadmium	>1	Surveys found no impact to the population.
	Oral and inhalation	Individual adult deer	Cadmium	>1	Surveys found no impact to the population.
	Aquatic toxicity at Spring 5	–	Copper	>1	No surface water currently present.

Table 3. Summary of hazards to ecological receptors identified in the Site 300 baseline risk assessment. (Cont. page 2 of 3)

Area	Exposure pathway	Receptor	Contaminant	Baseline hazard quotient	Comments
Building 850 Area	Oral and inhalation	Individual adult ground squirrels	Cadmium	>1	Surveys found no impact to the population.
	Oral and inhalation	Individual deer (J&A)	Cadmium	>1	Surveys found no impact to the population.
	Oral and inhalation	Individual ground squirrels	PCBs, dioxins, and furans	NC	Hazard indices were not calculated, but a literature review indicated individual animal were potentially at risk due to the ability of these compounds to bioaccumulate. Surveys found no impact to ground squirrel populations.
	Oral and inhalation	Individual deer	PCBs, dioxins, and furans	NC	Hazard indices were not calculated, but a literature review indicated individual animal were potentially at risk due to the ability of these compounds to bioaccumulate. Surveys found no impact to deer populations.
	Oral and inhalation	Individual kit fox	PCBs, dioxins, and furans	NC	Hazard indices were not calculated, but a literature review indicated individual animal were potentially at risk due to the ability of these compounds to bioaccumulate. Surveys found no evidence of kit fox in the area.
	Oral	Adult ground squirrels	Copper and cadmium	>1	Surveys found no impact to the population.
	Aquatic toxicity at Spring 6	–	Copper and zinc	>1	Bioassays indicate no hazard.
Building 854				NC	Majority of area paved, no ecological habitat.
Building 832 Canyon	All	All	All	<1	
Building 801	Oral and inhalation	Individual adult ground squirrels	Cadmium	>1	Surveys found no impact to the population.
	Oral and inhalation	Individual deer (J&A)	Cadmium	>1	Surveys found no impact to the population.
Building 802 Firing Table	All	All	All	<1	
Building 833	All	All	All	<1	
Building 845 Firing Table	–	–	–	NC	Data from this area added to other individual populations throughout the East and West Firing Areas.
Building 851 Firing Table	Oral and inhalation	Individual adult ground squirrels	Cadmium	>1	Surveys found no impact to the population.
	Oral and inhalation	Individual deer (J&A)	Cadmium	>1	Surveys found no impact to the population.

Notes appear on the following page.

Table 3. Summary of hazards to ecological receptors identified in the Site 300 baseline risk assessment. (Cont. page 3 of 3)

Notes:

J&A =	**Juvenile and adult.**
NC =	**Hazard quotients not calculated.**
PCBs =	**Polychlorinated biphenyls.**
PCE =	**Tetrachloroethylene.**
TCE =	**Trichloroethylene.**
VOCs =	**Volatile organic compounds.**

Data are from the Final Site-Wide Remedial Investigation Report (Webster-Scholten, 1994) Tables 6-74, 6-118, and 6-119.

Attachment A:
Risk-Based End State Vision Variance Report for Lawrence Livermore National Laboratory Site 300

Attachment A:
Risk-Based End State Vision Variance Report for Lawrence Livermore National Laboratory Site 300

This Attachment describes the variance between the Current Cleanup Baseline End State and the Risk-Based End State for LLNL Site 300.

<u>Variance 1: Point of Compliance for Ground Water</u>

Description of Variance:

The Current Cleanup Baseline End State assumes that all ground water contaminated by Site 300 activities must ultimately be remediated in a manner consistent with current environmental regulations and existing compliance agreements, both onsite and offsite. The impacted ground water body is assumed to be the point of compliance. The Risk-Based End State Vision assumes that the site boundary would be the point of compliance for contaminants in ground water. The Risk-Based End State Vision is not consistent with Federal and State environmental regulations and existing compliance agreements, in terms of onsite cleanup of ground water.

Variance Impacts:

An analysis of the time, cost, and scope to implement the Risk-Based End State Vision is not available. Without performing this analysis, it is not possible to compare these parameters to those for the Current Cleanup Baseline End State.

Barriers to Achieving a Risk-Based End State:

California Regional Water Quality Control Board Resolution 92-49, Section III.G., requires that cleanups be conducted in a manner that "promotes the attainment of either background water quality, or the best water quality that is reasonable if background levels of water quality cannot be restored." The Board does not recognize a site boundary, per se, as an alternate point of compliance. DOE has accepted Resolution 92-49 as an Applicable or Relevant and Appropriate Requirement for the cleanup of LLNL Site 300.

The Risk-Based End State is also contrary to enforcement documents signed by the DOE, the U.S. Environmental Protection Agency, the California Department of Toxic Substances Control, and the California Regional Water Quality Control Board. These documents include two Records of Decision for Site 300 that establish ground water cleanup standards no higher than Maximum Contaminant Levels, with the point of compliance being the impacted ground water body. In comments received by DOE on the Draft Risk-Based End State Vision, the regulatory agencies, local governments, and the public have stated that they expect DOE to honor the terms of these existing enforcement documents.

Recommendations:

Specific recommendations to address this Variance will be developed during preparation of the final Risk-Based End State Vision. Resolution of this issue will likely require EM-1 involvement with State regulators, EPA Region IX, local government, and the community.

United States Department of Energy
Livermore Site Office
Environmental Stewardship Division
7000 East Avenue, L-574
Livermore, California 94550